https://doi.org/10.35662/unine-thesis-2788

UNIVERSITÉ DE NEUCHÂTEL

Improving the work of surgeons

Identifying sources of stress and introduction of a tool to facilitate good teamwork in the operating room.

PhD Thesis submitted to the Faculty of Sciences

Institute of Work and Organizational Psychology

University of Neuchâtel

For the degree of PhD in Psychology

by

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Defended on May 29, 2019

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Titre:

"Improving the work of surgeons. Identifying sources of stress and introduction of a tool to facilitate good teamwork in the operating room"

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Summary

The profession of a surgeon is considered stressful, but not only is performing surgery stressful, but also stressors in and outside the operating room (OR) contribute to surgeons' stress. This dissertation examines possible stressors for surgeons in their daily work, inside and outside the OR. However, there are more people in the OR than just a surgeon, making surgery a team task. And because many errors during surgeries are due to cooperation problems, good communication in the OR is essential. To foster communication, an intraoperative briefing was introduced in four hospitals. Therefore, this dissertation is composed of two topics, the identification of stress sources (3 papers) and the introduction of a tool to facilitate good teamwork in the OR (4 manuscripts).

The first paper relates everyday work experiences of surgeons to felt stress. Surgeons worked an average of 11.86 hours per day. Performing surgery was rated as the most, and administration as the least attractive task. The extent to which the amount of administrative work was perceived as adequate was associated with job satisfaction. The second paper shows that second surgeons were more distracted by noise during the main operating phase and anesthetists more during the closing phase. The third paper evaluates the content of case-irrelevant communication (CIC) of the team during surgeries. Work-related CIC was more frequent than social CIC and less social and work-related CICs were observed in operations classified by surgeons as very difficult and in surgeries rated as highly difficult by the surgeons, less social and work-related CIC were observed.

The four manuscripts are all part of the StOP? project. In this project, the StOP? protocol, an intraoperative briefing aimed at enhancing information exchange, was introduced in four hospitals. At critical moments during each procedure, the surgeon interruptes the surgery and informes the team in terms of the current Status (St) and Objectives (O) of the surgery, Problems that may occur (P), and encourages questions of other team members (?). The manuscripts describe details of the conceptualization and development of the StOP? protocol and show that the compliance with it is good. Analyses also show that the StOP? positively influences the quality of the already established preoperative timeout briefing, increases situation awareness of anaesthesia and circulating nurses, and ease of speaking up for scrub nurses, anaesthesia, and circulating nurses.

Résumé

Chirurgien est considéré comme étant une profession stressante. Non seulement opérer est stressant, mais les facteurs de stress à l'intérieur et à l'extérieur de la salle d'opération contribuent au stress des chirurgiens. Cette thèse examine les facteurs de stress possibles pour les chirurgiens dans leur travail quotidien, à l'intérieur et à l'extérieur de la salle d'opération. En outre, il y a bien plus de monde dans le bloc opératoire que le seul chirurgien, ce qui fait de la chirurgie une tâche d'équipe. Étant donné que de nombreuses erreurs pendant les interventions chirurgicales sont dues à des

problèmes de coopération, une bonne communication au bloc opératoire est essentielle. Pour favoriser la communication, un briefing intraopératoire a été introduit dans plusieurs hôpitaux. Cette thèse est donc composée de deux sujets : l'identification des sources de stress (3 articles) et l'introduction d'un outil pour faciliter le travail en équipe en salle d'opération (4 manuscrits).

Le premier article faisait le lien entre les expériences de travail quotidiennes des chirurgiens et le stress ressenti. Les chirurgiens travaillaient en moyenne 11,86 heures par jour. La chirurgie a été classée comme la tâche la plus attrayante et l'administration comme la tâche la moins attrayante. La mesure dans laquelle la quantité de travail administratif était perçue comme adéquate était associée à la satisfaction au travail. Le deuxième article a montré que les chirurgiens secondaires étaient plus distraits par le bruit pendant la phase principale et les anesthésistes plus pendant la phase finale. Le troisième article évaluait le contenu de la communication sans rapport avec le cas (CIC) de l'équipe pendant les opérations. Le CIC lié au travail était plus fréquent que le CIC social et, dans les opérations jugées très difficiles par les chirurgiens, on a observé un CIC moins social et lié au travail.

Les quatre manuscrits font tous partie du projet StOP?. Dans le cadre de ce projet, le protocole StOP?, un briefing intraopératoire visant à améliorer l'échange d'information, a été introduit dans quatre hôpitaux. À des moments critiques de chaque opération, le chirurgien interrompt l'opération et informe l'équipe de l'état actuel (St) et des prochaines objectifs (O) de l'opération, des problèmes qui peuvent survenir (P), et il encourage finalement les questions des autres membres de l'équipe (?). Les manuscrits décrivent les détails de la conceptualisation et de l'élaboration du protocole StOP? et montrent que l’engagement (commitment) est bon.. Les analyses ont également montré que le StOP? influence positivement la qualité du briefing préopératoire déjà établi et favorise une meilleure connaissance de la situation des anesthésistes et des circulants, ainsi que la facilité de prise de parole des instrumentistes, des anesthésistes et des circulants.

Key words: surgeon stress, stressors in the operating room, briefings in the operation room, communication in surgical teams, teamwork in surgical teams, perceived stress in surgeons, surgeon’s well-being, briefing intervention, surgical checklist, compliance with an intervention, teamwork intervention, surgical teams

Mots clées: stress des chirurgiens, stresseurs dans la salle d'opération, briefings dans la salle d'opération, communication dans les équipes chirurgicales, travail d'équipe dans la salle d'opération, stress ressenti chez les chirurgiens, bien-être des chirurgiens, briefing comme intervention, checklist chirurgicale, adhésion à l’intervention, intervention dans le travail d’équipe, équipe chirurgicale

Acknowledgements

A very special thank you goes to my dissertation supervisor Franziska Tschan. She convinced me to write this dissertation and made it possible for me to do so. Her supervision was highly supportive and I learned a lot in the years of working with her. She was always more convinced of my abilities than I was.

A big thank you also goes to my colleague Sandra Keller. She introduced me to our team's projects, showed me how our data collection and processing works and was always open to questions. She was always a very pleasant office companion and a good colleague.

I would also like to thank Norbert Semmer, who repeatedly gave me valuable input on my work and proofread my manuscripts.

My thanks also goes to Guido Beldi, who provided valuable help in organizing our surgical projects, gave valuable feedback on articles from a surgeon's point of view and agreed to be part of my dissertation committee.

A big thank you also to all my colleagues from the IPTO. There was always a friendly atmosphere at the IPTO and everyone was always supportive. I would particularly like to mention Jasmin Zimmermann, Simon Huber and Camille Morgenthaler, with whom I have worked regularly on various projects and who have been pleasurable to work with. A particular thank you also to Ottilie Tilston for proofreading my dissertation and Adrian Bangerter for agreeing to be part of my dissertation committee.

I would also like to thank everyone who participated in our studies. All surgeons, assistants, nurses and anaesthetists we were allowed to observe and who filled in our questionnaires. Thank you also to all the secretaries, technicians and study nurses within the hospitals who supported us with data collection. Of course, I would also like to thank all the psychology students who supported our data collection with observations.

Finally, I would also like to thank my parents, who made it possible for me to study psychology in the first place and thus also to do my doctorate. They are always there for me and I can fully rely on their support no matter what.

And last but not least, I would like to thank my husband for his everyday support. For the emotional support and understanding when I did not have time for him or to help in the household.

Abstract

This dissertation is composed of three papers and four manuscripts. The papers form the first main topic of this thesis, identifying sources of stress. The manuscripts form the second main topic, introduction of a tool to facilitate good teamwork in the operating room.

The first paper (The workday of hospital surgeons: What they do, what makes them satisfied, and the role of core tasks and administrative tasks; a diary study) aimed to relate everyday work experiences of surgeons to felt stress. For this, 105 surgeons responded to a general questionnaire regarding their working conditions, 87 of them also participated in a diary study. Surgeons worked a mean of 11.86 hours per day. About one fifth each was spent on tasks directly related to surgery (21.2%) and to patients (21.7%); about ten percent (10.4%) on meetings and communicating about patients, and somewhat less than one fifth (18.6%) on documentation and administration. Performing surgery – a surgeon's core activity- was rated as the most, and administration as the least attractive task. The higher the percentage of administrative work, the lower was its perceived adequacy. The extent to which the amount of administrative work was perceived as adequate was associated with job satisfaction.

The second paper (Noise in the Operating room distracts member of the surgical team. An observational study) examined how noise pollution in operating rooms (OR) may distract members of the surgical team. Especially during phases of high task complexity, noise can jeopardize concentration. Phases of high complexity are related to specific characteristics of the tasks and can therefore be different for the different members of the surgical team. Noise exposure was measured during 110 surgeries and related to self-report of distraction by main and secondary surgeons, scrub nurses and anesthetists participating in the surgeries. Second surgeons were more distracted by noise during the main phase and anesthetists more during the closing phase. The concentration of the other team members were not impaired.

The third paper (More than talking about the weekend: content of case-irrelevant communication within the OR team) evaluated the content of case-irrelevant communication (CIC) of the team during surgeries and whether they regulate CIC according to different concentration demands (surgical phases and difficulty of surgery). In 125 surgeries, 1396 CIC events were observed. Work-related CIC was significantly more frequent (2.49 per hour) than social CIC (1.42 per hour). Across phases, frequency of work-related CIC was constant, whereas social CIC increased significantly. In surgeries rated as highly difficult by the surgeons, less social and work-related CIC were observed.

The analyses in the four manuscripts are all part of a larger project, the StOP? project. In this project, the StOP? protocol, an intraoperative briefing aimed at enhancing information exchange within the surgical team, was introduced in surgical departments of four hospitals. At critical moments during each procedure, the leading surgeon interrupted the surgery and informed the team in terms of the current Status (St) and Objectives (O) of the surgery, Problems that may occur (P), and encouraged questions of other team members (?).

The first manuscript (Preparation and implementation of intraoperative briefings to enhance teamwork during surgeries: The StOP? Protocol) describes details on the conceptualization and development of the StOP? protocol. To adapt the StOP? protocol to the operation room and pinpoint the right moment for the StOP?, interviews with 23 surgeons were carried out and analyzed. Several surgeons mentioned similar preferred points to conduct a StOP?, such as after initial exposure, before important steps, and before or after anastomosis. The demand of the surgeons for a StOP? nevertheless varied for different kinds of surgeries and local practice.

The second manuscript (Context and task-related factors influencing the compliance of surgical teams with an intra-operative briefing intervention) analysed the compliance with the StOP? protocol. Possible positive effects of briefing interventions depend on compliance of the surgical team. Compliance with the StOP? protocol was measured and factors influencing compliance were evaluated. Compliance was measured using a post-surgery questionnaire filled in by scrub nurses. Results of three hospitals show that nurses provided information in 79.1% of eligible surgeries. In these surgeries, compliance rate (at least one StOP? protocol) was 83.6%. Influences on compliance were hospital, urgency (elective vs emergency), duration, and surgical access (minimal invasive vs open surgery).

The third manuscript (Two are better than one – Introducing an intra-operative briefing enhances the quality of an established pre-operative briefing: a pre-post intervention study) analysed if and what influences the newly introduced StOP? has on the quality of the already established preoperative timeout (briefing before skin incision). Observers rated the quality of the timeout in 267 surgeries in two hospitals. As compared to the baseline, after the implementation of StOP?, observed timeouts were rated significantly less noisy, higher in engagement, less rushed, in a better social atmosphere and had a higher rate of completion.

The fourth manuscript (Supporting situation awareness and ease of speaking up by a short intervention to foster information exchange during surgical procedures: An intervention study) compared situation awareness and ease of speaking up of surgical team members during surgeries before and after the introduction of the StOP?. Members of the OR team filled in self-report questionnaires at the end of 371 surgeries in three hospitals. The intervention improved situation

awareness of anaesthesia and circulating nurses. Ease of speaking up was enhanced for scrub nurses, anaesthesia care providers, and circulators.

The contribution and implications of each paper and manuscript in means of the dissertation topics are discussed as well as the limitations and future perspectives of the present work.

Contents

Introduction

Surgery is not only a high risk but also a complex event. To handle surgeries, surgeons undergo many years of training and specialisation, acquiring the skills needed to perform surgery. A surgery itself can be a highly stressful event. It is a critical task, and any wrong action could jeopardize the well-being, or even the life of the patient. Nevertheless, it is not just the task of doing surgery itself that accounts to this stress. There are certain stressors in the environment of the operation room (OR) which can contribute to stress, and even outside the OR the surgeons are faced with possibly stress-inducing parts of their job. Therefore, being a surgeon is considered a stressful profession (Anton, Montero, Howley, Brown, & Stefanidis, 2015).

There is a great deal of research on the topic of surgeon's stress. This dissertation aims to contribute to it and to extend it by investigating certain aspects of it in more detail and in a more differentiated way. A lot of research has been done on stress inducing stressors during the surgery (Sevdalis, Forrest, Undre, Darzi, & Vincent, 2008; Wong, Smith, & Crowe, 2010). The aim of this dissertation is on one hand to shed light on the more precise mechanisms of two certain stressors. On the other hand, to identify possibly stressors for surgeons which are found outside the OR in their workday.

However, surgery is not performed by the surgeon alone. There are at least an anaesthetist (controlling the patient vital status), a scrub nurse (handing instruments to the surgeon) and a circulating nurse (providing material not already on the table) in the OR, assisting the surgeon. All of them are trained in their respective field. Since surgery is a team task, surgical performance depends not only on the technical skills of all team members, but also on their respective non-technical skills (cognitive and social skills) (McCulloch et al., 2017; Youngson & Flin, 2010). Although teamwork in healthcare gets progressively more attention, collaboration problems in the OR persist (Sundler, Johansson, Johansson, & Hedén, 2018; Weigl et al., 2018). Therefore, good communication and coordination in the OR between the team members is important, but miscommunications and breakdowns in the OR are frequent during surgeries (Gillespie, Chaboyer, & Fairweather, 2012; Lingard et al., 2004). In addition, many errors and mishaps which happen during surgeries are due to problems in cooperation (ElBardissi, Wiegmann, Dearani, Daly, & Sundt, 2007; Hu, Arriaga, Roth, et al., 2012; Wauben et al., 2011).

Problems with cooperation can cause various other problems, which can also disturb the work of the surgeon, making her or his work more stressful. In contrast, a well-functioning team can be a resource for the surgeon by making their work less stressful. Although stressors in surgeons' work environment is an important element concerning the work of a surgeon, their work is also heavily influenced by the teamwork in the OR. For this dissertation, I therefore chose to cover an additional

topic, related to the work of surgeons. Good teamwork improves the work of the surgeon, but there is still a lack of teamwork interventions, especially in the OR itself (Ounounou et al., 2019). Our research team developed such a team intervention, an intraoperative briefing, a tool to facilitate good teamwork in the OR. In this dissertation, I examine the effects this tool has on teamwork in the OR and discuss it as possible resource for surgery in general and for the work of surgeons.

This thesis therefore consists of two main topics, stress in surgery and effects of an intraoperative briefing in the OR. On one hand, I am interested in the working conditions of surgeons, especially what stresses them. On the other hand, I am interested in coordinative aspects and effects of an intervention to enhance teamwork in surgery.

This thesis is composed of seven studies (3 papers, 4 manuscripts) with each corresponding to one of the two main topics. The two main topics are divided into chapters, in which I give additional information to the main topics, to the specific topics of the studies, and linking to the main topics. Each paper or manuscript is inserted after the chapter corresponding to the respective topic. Naturally, as the chapters are extensions of the studies' topics, there will be overlaps, repetitions, and similar phrasing between the studies and the chapters. The papers will be presented in the format they were submitted, the manuscripts in the format of the journal where they are planned to be submitted or simply as draft in APA format. References used in the papers and manuscripts are listed after the respective paper or manuscript. All other references used in this thesis are listed at the end; therefore, the overall page numbering will skip over the inserted papers and manuscripts to ensure that all citations stay in the right place.

Chapter 2 consists the first of the two overall topics of this thesis (surgeon stress). I mainly concentrate on aspects of stress during surgeries, particularly from the perspective of surgeons. Chapter 2 gives a short general introduction to the topic of stress in the OR, chapter 2.1 then briefly describes stressors in surgery. Chapter 2.2 gives further background on the paper "The workday of hospital surgeons: What they do, what makes them satisfied, and the role of core tasks and administrative tasks; a diary study" (paper itself inserted as chapter 2.3). Chapter 2.4 provides further information on the paper "Noise in the Operating room distracts member of the surgical team. An observational study" (paper itself inserted as chapter 2.5). Chapter 2.6 outlines information on the paper "More than talking about the weekend: content of case-irrelevant communication within the OR team" (paper itself inserted as chapter 2.7). For the sake of simplicity, I will refer to the papers as "the workday paper" (chapter 2.3), "the noise paper" (chapter 2.5) and "the communication paper" (chapter 2.7).

Chapter 3 covers the second overall topic (effects of an intraoperative briefing in the OR). The introduction of our intraoperative briefing, the StOP? protocol, in the OR and its effects on the surgical team. It starts with a short general introduction on teamwork and communication in the OR (chapter

3.1). Chapter 3.2 then provides broader and connecting information on all four manuscripts of the second main topic, instead for one for every paper. I chose this change in structure compared to the first part to evade repetition and improve readability, since the manuscripts on this topic are thematically very close and therefore overlapping a lot. Then the manuscripts are inserted as chapters consecutively. As chapter 3.3, the manuscript "Preparation and implementation of intraoperative briefings to enhance teamwork during surgeries: The StOP? Protocol" is inserted. As chapter 3.4, the manuscript "Context and task-related factors influencing the compliance of surgical teams with an intra-operative briefing intervention" is inserted. As chapter 3.5, the manuscript "Two are better than one – Introducing an intra-operative briefing enhances the quality of an established pre-operative briefing: a pre-post intervention study" is inserted. As chapter 3.6, the manuscript "Supporting situation awareness and ease of speaking up by a short intervention to foster information exchange during surgical procedures: An intervention study" is inserted. For the sake of simplicity, I will refer to the manuscripts as "the StOP? introduction paper" (chapter 3.3), "the compliance paper" (chapter 3.4), "the timeout paper" (chapter 3.5), and "the StOP? team paper" (chapter 3.6).

Chapter 4 is the closing chapter where the main results from the papers are outlined and discussed. To match the overall structure of the thesis, the discussion is split in two parts (stress and briefing part) with an additional third part which discusses points found in both topics and connections which can be drawn between the topics. For each of the two parts, the limitations and future research, and the implication for the practice are each a separate section. Then in the final chapter 5, the conclusions are presented.

All papers and manuscripts are related to the work of surgeons and bring valuable results, which may help to improve the work of surgeons in various ways.

During my work on this dissertation I also co-authored a paper, which is not part of this dissertation. It is provided in the appendix.

2. Stress in Surgery

The first part of this thesis is about different sources of stress, which can appear in and outside the OR. This is a relevant topic because stress is also an important factor for surgeons. This chapter contains a short overview on the topic of stress in surgeons and serves as overall introduction for the first part of this thesis.

Many surgeons regard their profession as fascinating, citing feelings of passion as an important reason for doing surgery (Incorvaia, Ringley, & Boysen, 2005), or even referring to surgery as a calling (Seelandt, Kaderli, Tschan, & Businger, 2014). Medical students in their final year who

intend to specialize in surgery cite enjoyment of surgery and its procedural aspects as important reasons for their career choice (Boyle et al., 2013).

At the same time, doing surgery is considered difficult and stressful (Vijendren, Yung, & Sanchez, 2014; von dem Knesebeck, Klein, Frie, Blum, & Siegrist, 2010). Even though moderate stress levels can positively affect overall surgical performance by improving focus and alertness (Wetzel et al., 2006), long lasting and enormous stress levels can impair technical (Arora, Sevdalis, Aggarwal, et al., 2010; Hassan et al., 2006) and non-technical skills (Arora, Sevdalis, Aggarwal, et al., 2010; Wetzel et al., 2010). Impairment of these skills can lead to undesirable events in the OR and therefore be a risk for patient safety (Weenk et al., 2018).

Not only patient safety is at risk due to stress. Chronic stress may harm the person experiencing it. It can lead to job-dissatisfaction (Shields, 2006), promote health issues like depression or burnout (Dimou, Eckelbarger, & Riall, 2016; Oskrochi, Maruthappu, Henriksson, Davies, & Shalhoub, 2016), and can increases the risk of cardiovascular diseases (Lagraauw, Kuiper, & Bot, 2015; Marrelli, Gentile, Palmieri, Paduano, & Tatullo, 2014).

Surgeons report lower job satisfaction than other physicians (Jurkat & Reimer, 2001), and about a fifth of hospital surgeons think about giving up their profession several times a month (von dem Knesebeck et al., 2010). Surgeons also report a higher number of health complaints (Boerjan, Bluyssen, Bleichrodt, Van Weel-Baumgarten, & Van Goor, 2010) and lower quality of life as compared to the population at large (Bohrer, Koller, Schlitt, & Bauer, 2011), and as compared to other medical specialties (Bohrer et al., 2011; Jurkat & Reimer, 2001).

This shows that surgeons are often subject to stress, and this stress has the risk of negative consequences for patients and the surgeons themselves. Therefore, it is important to know what exactly the factors are which induce this stress.

2.1 Stressors in Surgery

During the operating procedure, the surgeons face different kinds of potential stressors (Arora et al., 2009). Stressors such as patient complications (Weenk et al., 2018), teamwork problems, management issues (Arora, Hull, et al., 2010), time issues (Anton et al., 2015; Wetzel et al., 2006), and challenges like getting used to new techniques (Berguer, Smith, & Chung, 2001; Munch-Petersen & Rosenberg, 2008). Also distractions such as different kinds of noises (Moorthy, Munz, Undre, & Darzi, 2004), and technical problems (Arora, Hull, et al., 2010) can pose difficulties during surgery. The list of potential stressors in the OR continues to grow (Sevdalis et al., 2008; Wong et al., 2010), contributing to surgery bearing considerable risks for stressful events.

However, doing surgery is not the only task surgeons have to do in their job. There are other tasks that are elements of a surgeon's everyday work. Tasks such as documentation and administration, ward rounds, meetings with patients or other medical staff, and more (Dassinger III, Eubanks III, & Langham Jr, 2008; Gabow et al., 2006; Mache et al., 2010). Research about surgical stress often focuses on what happens in the operating room, but rarely includes the whole work environment (Becker, Ellis, Goldsmith, & Kaye, 1983; Demirtas et al., 2004; Jones et al., 2015). To assess surgeon's stress to the full extent, other tasks in the workday of a surgeon need to be included in analyses. These tasks and the stress they trigger, possibly have consequences for the overall quality of work (Weenk et al., 2018). If we want to understand the work of surgeons and the interrelations between the different aspects of their work, assessing their everyday work is important, the analyses only of stressors during surgery is not enough.

2.2 Stress as part of the Surgeon's Workday

As compared to other medical professions, surgeons report higher workload and higher stress levels (Bohrer et al., 2011; von dem Knesebeck et al., 2010). Among the most often mentioned stressful aspects of surgeon's work is high workload (Seelandt, Kaderli, et al., 2014), and long working hours (Balch et al., 2010; Boerjan et al., 2010; Bohrer et al., 2011; Jurkat & Reimer, 2001). This is related to high exhaustion (Balch et al., 2010), which is the main component of burnout, making workload a relevant contributor to burnout (Oskrochi et al., 2016). Furthermore, surgeons report an impaired balance between work and private life, which, again, is related to long working hours and exhaustion (Balch et al., 2010; Bohrer et al., 2011; Dyrbye et al., 2011; Seelandt, Kaderli, et al., 2014).

Quite a few studies indicate that being stressed and overworked may increase the risk of errors and poor patient care, although there are large inter-individual differences (Arora, Sevdalis, Nestel, et al., 2010; Klein, Frie, Blum, & von dem Knesebeck, 2011; Wetzel et al., 2006).

In sum, surgeons often report high levels of workload, stress, and impaired well-being to the extent that some consider giving up surgery (Ginther, Dattani, Miller, & Hayes, 2016; von dem Knesebeck et al., 2010), even after the considerable time of training and despite reporting a passion for surgery (Incorvaia et al., 2005). Those findings are based on studies that are, for the most part, rather general evaluations of the work situation of surgeons, which are important indicators and help to point to the importance of the problem.

However, in order to identify where exactly the high workload and stress originates, to point to potential interventions to limit stress, and to keep engaged surgeons in the profession, a more

detailed picture of the everyday working life of surgeons is needed in terms of what they actually do during the workday. Such an analysis needs to include surgery as the core task, but also the other – non-core tasks – that surgeons perform every day. This also needs to include tasks which surgeons like and prefer, the perceived legitimacy of those tasks (Semmer et al., 2015), the time allocated to the different tasks, as well as their contribution to satisfaction.

The study presented in the next chapter provides detailed information about how hospital surgeons spend their day. The study looked at what are the daily tasks in a surgeon's workday, how much of the work time these tasks take up, and the tasks perceived attractiveness (enjoyment, inconvenience, and legitimacy of doing the task).

2.3 Paper on the Daily Workday of Surgeons

This chapter contains the paper on the daily workday of surgeons with the title: "The workday of hospital surgeons: What they do, what makes them satisfied, and the role of core tasks and administrative tasks; a diary study" which is currently under review.

The workday of hospital surgeons:

What they do, what makes them satisfied, and the role of core tasks and administrative tasks; a diary study

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Research article

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Abstract

Background: Many surgeons report passion for their work, but not all tasks are likely to be satisfying. Little is known about how hospital surgeons spend their days, how they like specific tasks, and the role of core-tasks (i.e. surgery-related tasks) versus tasks that may keep them from core tasks (e.g., administrative work). This study aimed at a more detailed picture of hospital surgeons' daily work - how much time they spend with different tasks, how they like them, and associations with satisfaction.

Methods: Hospital surgeons (N = 105) responded to a general survey and daily questionnaires concerning daily activities and their attractiveness, as well as the surgeons' job satisfaction.

Results: Among 14 tasks, surgery-related tasks took 21.2%, patient-related tasks 21.7% of the surgeons' time; 10.4% entailed meetings and communicating about patients, and 18.6% documentation and administration. The remaining time was spent with teaching, research, leadership and management, and not task-related activities (e.g. walking between rooms). Surgery was rated as most (4.25; *SD* = .66), administration as least attractive (2.63; *SD* = .78). A higher percentage of administration predicted lower perceived legitimacy; perceived legitimacy of administrative work predicted job satisfaction (r = .47). Junior surgeons were least satisfied; there were few gender differences.

Conclusions: Surgeons seem to thrive on their core tasks, most notably surgery. By contrast, administrative duties are likely perceived as keeping them from their core medical tasks. Increasing the percentage of medical tasks proper, notably surgery, and reducing administrative duties may contribute to hospital surgeons' job satisfaction.

Keywords: Hospital surgeons; daily activities; task attractiveness; core tasks; administration; job satisfaction

BACKGROUND

Many surgeons see their profession as fascinating, citing feelings of passion as a reason for being a surgeon [1], or referring to surgery as a calling [2]. At the same time, about a fifth of hospital surgeons think about giving up their profession several times a month [3]. Furthermore, the prevalence of depression and burnout among surgeons is rather high, and so is suicide [4,5].

Such problems are likely connected with high workload and long working hours [6-8] and the related issues of high fatigue/exhaustion [6] (the main component of burnout), and with an impaired balance between work and private life [6,7,2,5].

To some extent, however, such problems might be associated with the nature of the tasks themselves. Specifically, tasks that are not properly surgical and not directly related to patient care, most notably a high percentage of administrative work, are often cited as reasons for stress and dissatisfaction [7,9,10,2]. These findings are mainly based on studies that represent rather general evaluations of the work situation; much less is known about the daily life of surgeons. To tailor attempts at optimizing conditions to the specific circumstances at work, we need a more detailed picture of what the daily working life of surgeons looks like, what they actually do, and what they like most and least about their work. In this study, hospital surgeons responded to a number of daily questionnaires in addition to a general survey. Such a diary approach is less prone to bias by errors of memory than general surveys [11].

METHODS

Recruitment and participants

The research team sent an information letter to public hospitals in the German-speaking part of Switzerland, explaining the purpose of the study and the process of data

collection. Of 71 hospitals contacted, 26 agreed to inform their surgeons, 11 refused to participate, and 34 did not respond. Surgeons from 22 different hospitals participated in the study. Classified according to the Swiss Medical Association (http://www.siwf-register.ch), one of the participating hospitals (4.6%) was a University hospital, 9 (40.9%) were primary referral centers (type A, offering 4 years of surgical training), 4 (18.8%) were secondary referral hospitals (type B3, offering three years of training) and 8 (36.4%) were small regional surgical departments (one type B1; seven B2, offering one or two years of training). Thus, type A hospitals were overrepresented (40.9% versus 19.2%), and B1 hospitals were underrepresented (4.6% versus 19.2%).

In 18 participating hospitals, the research team directly presented the study at the hospital; for four hospitals, the information was provided by electronic mail. After being informed about the study, 132 surgeons signed up for participation and received a detailed information package. Subsequently, 27 surgeons withdrew their agreement – two because of lack of time, one because of imminent retirement; 24 did not provide a reason.

The final sample consists of 105 surgeons; (40) 38.1% were female. Mean age was 37.4 years (*SD* = 10.46, *RANGE* = 24-64). Positions were chief of staff (14; 13.33%), consultant (13; 12.38%), senior resident (30; 28.57%), and junior resident (48; 45.71%). Mean tenure in the current hospital was 4.49 years (*SD* = 6.18; *RANGE* 0-30). With reference to the 132 surgeons who initially had agreed to participate, the response rate was 79.5% (105/132) for the general questionnaire, and 61.4% (81/132) for the daily questionnaires.

Overall, 81 surgeons provided 374 daily records, reporting data on 4.6 days on average (67 for 5 days; 7 for 4, 1 for 3; 2 for 2, and 4 for 1). Excluding daily records that did not specify the time spent on specific tasks resulted in 338 daily records included in the analyses.

Procedure

Questionnaires were delivered via e-mail. The general survey contained demographic questions and general questions about the participants' work, not all of which are reported here. After completing the survey, participants provided five dates during which they worked at the hospital and could respond to daily questionnaires; on each of these they received an email in the morning containing a personalized link to the questionnaire of the day. We recommended answering the daily questionnaires late afternoon, because typically no regular surgeries are scheduled at this time. Questionnaires were presented online, using Qualtrics (Provo, UT).

Measures

General survey

The general survey asked about demographics (age, sex, position, etc.), and about general working conditions. Concerning the latter, job satisfaction and perceived opportunities for training are reported in this paper. General job satisfaction was assessed with an item ranging from 1 (exceptionally dissatisfied) to 7 (exceptionally satisfied); the verbal descriptions were combined with faces that look more or less satisfied [12]. Training opportunities were assessed with four questions, such as "inexperienced colleagues have sufficient opportunity to profit from skills and knowledge of the more experienced ones". Answers ranged from 1 (not true) to 5 (completely true); reliability (Cronbach's alpha) was $\alpha = 0.85$.

Daily questionnaire

For each of 14 tasks (see Table 1) the surgeons specified whether they had performed the task within the last 24 hours (no, once, several times), how much time they had spent on each task (hours; minutes), and how attractive they perceived the task to be on a 5 point Likert Scale ranging from 1 (very negative) to 5 (very positive). The 14 task categories were based on pilot interviews with 50 surgeons. To assess whether surgeons considered a task as a

legitimate part of their duties, it was also asked if a task made sense and whether they considered it necessary and reasonable that *they* carried out this task (answering format was a 5 point Likert scale ranging from 1 (absolutely not) to 5 (very much).

Regarding administrative duties, we asked two questions concerning perceived adequacy ("do you think the demand for administrative work in the last 24 hours a) was adequate, b) kept you from important medical activities?"; answers ranged from 1= not true to 5 = very true); the two questions were combined; Cronbach's alpha for this score was .83.

Current job satisfaction was assessed each day with the question "Regarding my situation at work overall, I am currently…extremely dissatisfied (1) to extremely satisfied (7)"; verbal answers were combined with faces as in the general questionnaire [12].

Analyses

Daily questionnaire data were aggregated within individual surgeons. Means and standard deviations are reported for numerical data, counts and percentages for categorical data. Using SPSS 21.0 [13], we analyzed data by t-tests and analysis of variance; when appropriate, we controlled for covariates using Analysis of Covariance (ANCOVA). Repeated measures analysis of variance with Bonferroni correction was used for comparing means across tasks, Tukey's HSD test for post hoc analyses. We considered $P<.05$ as significant for all analyses.

RESULTS

How surgeons spend their days

Time spent performing specific tasks

As shown in Table 1, participants spent approximately 2 ½ hours with surgery-related tasks (doing or preparing surgery). Another 2 ½ hours were spent with individual patient work, 1¼ hours with meetings and team communication about patients; somewhat less than an hour (47 minutes) with continuing education, teaching and research; approximately 27

minutes with management and leadership, and approximately 2¼ hours with documentation and administration (see Table 1 for the exact values).

Position differences

Significant differences in time spent on tasks between the positions concerned (a) ward rounds $F(2, 73) = 4.42$, $p = .015$, $\eta^2 = .11$, with junior residents spending more time doing ward rounds than chiefs/consultants ($p = .006$) and senior residents ($p = .013$); (b) teaching $F(2, 73) = 3.78$, $p = .027$, $\eta^2 = .09$, which was hardly done by junior residents; (c) leadership, $F(2, 73) = 12.80$, $p < .001$, $\eta^2 = .26$, which was not done at all by junior residents, and (d) patient documentation, $F(2, 73) = 11.42$, $p < .001$, $\eta^2 = .24$, with junior residents doing more patient documentation than both chief/consultants and senior residents (both: $p < .001$).

Controlling for position, only patient documentation showed a gender effect, $F(1, 73) = 4.13$, $p = .046$, $\eta^2 = .054$, with women spending more time on this task than their male colleagues.

Tasks	Time spent with task				How much they liked doing the task (1 (very negative) - 5 (very positive))				
	overall N=78	chief of staff/consultant N=23	senior resident N=22	junior resident N=33	overall	chief of staff/consultant	senior resident	junior resident	
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD) N	M (SD) N	M (SD) N	M (SD) N	
Surgery-related									
Performing surgery	2h20m (1h4m)	2h38m (1h23m)	2h41m (1h50m)	1h53m (1h48m)	4.25(.66) N=68	4.28(.44) N=22	4.34(.67) N=22	4.13(.81) N=24	
Preparing surgery	13m (14m)	14m (13m)	16m (16m)	10m (13m)	4.06(.60) N=58	4.18(.57) N=19	4.11(.54) N=20	3.89(.69) N=19	
Individual patient work									
Medical consultations*	1h10m (1h)	1h31m (57m)	1h7m (50m)	58m (1h06m)	3.76(.59) N=63	4.02(.34) N=20	3.92(.51) N=19	3.41(.65) N=24	*junior residents rated it as less attractive than the others
Ward Rounds*	58m (41m)	43m (21m)	45m (25m)	1h16m (52m)	3.83(.60) N=74	4.04(.52) N=23	3.96(.50) N=22	3.57(.65) N=29	*junior residents spent more time than chiefs/consultants and senior residents & rated it as less attractive than others / women rated it as more attractive than men
Patient related conversations*	25m (20m)	25m (21m)	17m (13m)	29m (23m)	3.58(.65) N=66	3.89(.49) N=19	3.67(.50) N=19	3.31(.74) N=28	*junior residents rated it as less attractive than the others
Meetings / team communication about patients									
Daily meetings	45m (23m)	39m (17m)	45m (25m)	49m (24m)	3.53(.67) N=76	3.62(.60) N=23	3.5(.64) N=22	3.49(.74) N=31	
Specific meetings* (e.g., tumorboard)	14m (14m)	17m (15m)	13m (11m)	13m (17m)	3.63(.78) N=48	3.88(.68) N=18	3.42(.77) N=14	3.53(.87) N=16	*women rated it as more attractive than men

Other discussions about patients*	16m (18m)	16m (16m)	17m (18m)	15m (20m)	3.56(.72) N=50	3.96(.63) N=15	3.54(.56) N=17	3.24(.79) N=18	*junior residents rated it as less attractive than chiefs/consultants. Women rated it as more attractive than men
Teaching / Research									
Continous education	16m (25m)	18m (31m)	12m (11m)	16m (27m)	4.05(.76) N=44	4.4(.53) N=13	4.02(.66) N=15	3.79(.93) N=16	*junior residents rated it as less attractive than chiefs/consultants. Interaction position x gender: male junior residents rated it as less attractive than male senior residents, female junior residents rated it as more attractive than female senior residents.
Research	17m (40m)	12m (33m)	22m (41m)	17m (43m)	3.89(.65) N=24	4.08(.66) N=6	3.89(.80) N=10	3.75(.46) N=8	
Teaching*	14m (25m)	20m (26m)	23m (32m)	5m (12m)	4.22(.50) N=42	4.32(.47) N=17	4.17(.46) N=16	4.13(.62) N=9	*junior residents spent less time than senior residents
Leadership and Management*	27m (55m)	1h14m (1h20m)	18m (26m)	0m (0m)	3.81(.63) N=34	3.81(.56) N=19	3.81(.76) N=14	4(.00) N=1	*junior residents spent less time than chiefs/consultants who, in turn, spent more time than senior residents
Documentation and administration									
Patient documentation *	1h25m (1h05m)	51m (36m)	1h (39m)	2h06m (1h13m)	2.96(.67) N=72	3.19(.45) N=22	3.14(.65) N=21	2.66(.72) N=29	*junior residents spend more time than chief/consultants and senior residents. Women spent more time than men / junior residents rated it as less attractive than the others
General Administration*	46m (36m)	42m (30m)	40m (37m)	53m (39m)	2.63(.78) N=72	2.88(.67) N=21	2.79(.85) N=22	2.32(.70) N=29	*junior residents rated it as less attractive than the others. Women rated it as more attractive than men
Other (e.g. lunch-breaks, private calls)	5m (13m)	9m (17m)	3m (13m)	3m (11m)	3.62(1.19) N=13	3.71(1.11) N=7	3 (1) N=3	4 (1.73) N=3	
Miscellaneous (e.g. walking between rooms, waiting)	2h2m (2h2m)	1h33m (1h54m)	2h40m (2h11m)	1h58m (1h59m)					

Attractiveness of tasks

Columns 6 – 9 of Table 1 reveal that the surgeons perceived tasks directly related to surgery as very attractive. Teaching and continuous education also received high ratings. By contrast, administrative task received the lowest rating by all groups. More specifically, repeated measures ANOVA showed that the task that is liked most is performing surgery; it is rated as more attractive than eight other tasks (administration, patient documentation, patient related discussions [including calls from general practitioners], daily meetings, special meetings, consultation hours, ward rounds). Teaching is next, which is liked significantly more than seven other tasks. The two tasks that were liked the least were administration and patient documentation, which were perceived as significantly less attractive than all the other tasks.

Whenever there were significant differences between positions, it was junior residents who rated the respective task as less attractive than the others. Whenever gender differences were found, it was women who rated the respective task as more attractive than men. Male junior residents evaluated further training as less attractive than the male senior residents, but female junior residents evaluated further training as more attractive than female senior residents.

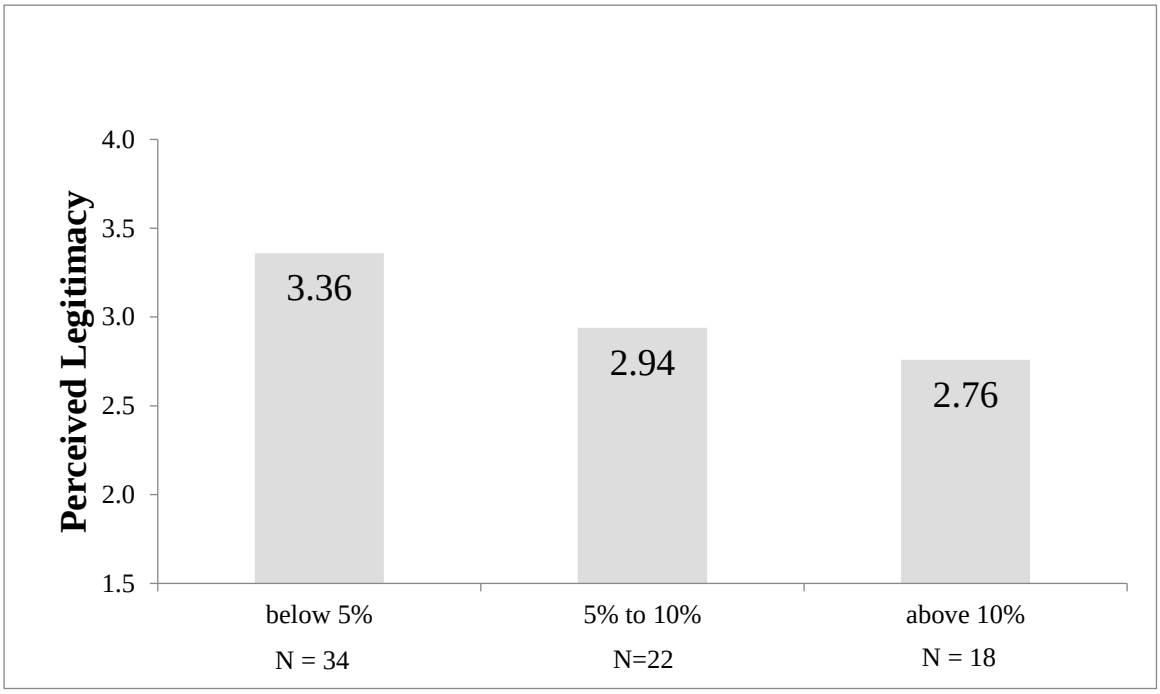
Administrative tasks and the issue of legitimacy

As described above, participants noted in the daily questionnaires if they considered that a task they carried out made sense, and whether it was necessary and reasonable that *they* carried out this task, indicating the perceived degree of legitimacy [14]. A repeated measures ANOVA showed that surgery-related tasks were rated as more legitimate than five other tasks, making them the tasks that were perceived as most legitimate of all (mean legitimacy = 4.48 for surgery, 4.53 for preparing for surgery). Administration was rated as significantly less legitimate than every other task, followed by writing patient documentation, which was rated

as less legitimate than six other tasks (mean administration = 3.12, mean patient documentation= 3.68).

We also asked two questions about the amount of administrative duties over the work day in terms of their perceived legitimacy (see Methods section). The combined value of these two items was correlated with the proportion of time spent with administrative duties at r = -0.313, p = .007. Thus, as the proportion of administrative tasks increases, their perception as being inadequate and keeping one from important medical tasks increases as well, indicating low legitimacy. Figure 1 shows how the values for perceived legitimacy of administrative work decrease as its proportion increases.

Figure 1. Amount of Administrative Work and its Perceived Legitimacy.

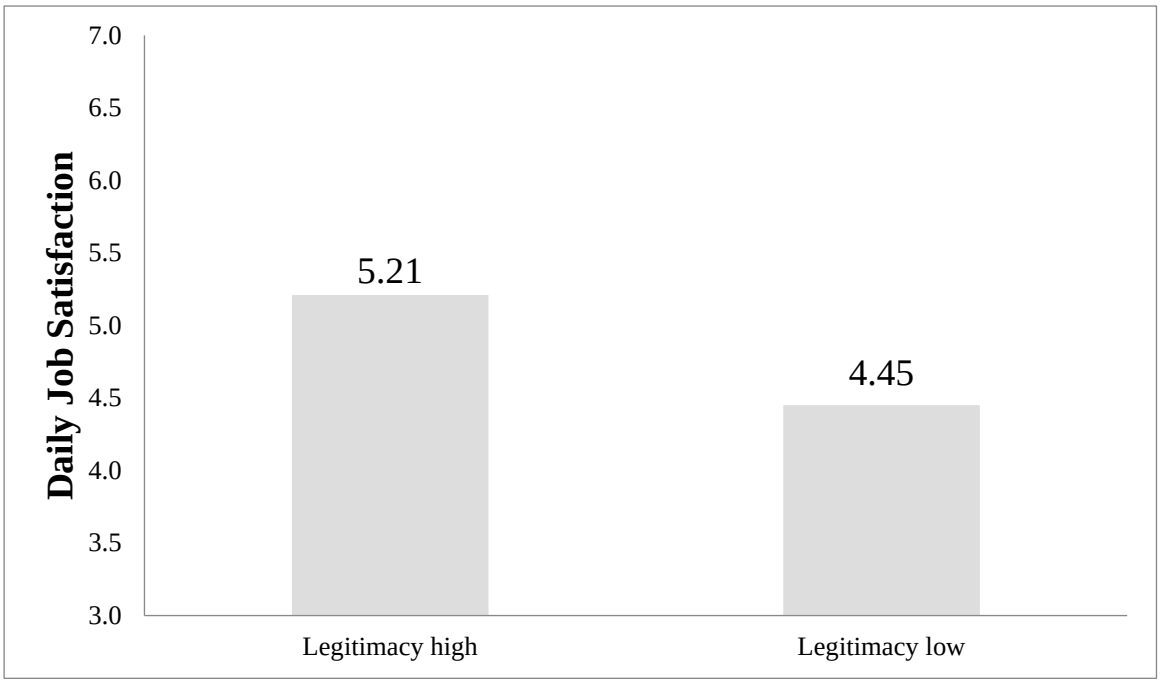


Daily Satisfaction

The overall mean for daily job satisfaction was 4.87; differences between positions were not significant, although values for junior residents were comparatively low (4.49). Daily job satisfaction was not significantly related to the sheer amount of administrative work. However, the extent to which the surgeons saw administrative work as being their proper duty and not keeping them from important medical work (i.e., as legitimate) was

significantly associated with job satisfaction (r = .467). The corresponding difference in job satisfaction between surgeons with high (n = 38) versus low (n = 35) judgments of legitimacy is shown in Figure 2; Daily job satisfaction was significantly different between the two groups; t(71)=3.68, p < .001.

Figure 2. Perceived Legitimacy of Administrative Work and Daily Job Satisfaction.



Surgery was the most preferred task; however, job satisfaction was not significantly correlated with hours spent in surgery (r = .13); it was, however, correlated with the extent to which doing surgery was experienced as positive (r = .418, *p* <.001); it was also associated with the extent to which surgeons were satisfied with the responsibility they could assume during surgery (r = .408, *p* =.001). Thus, a positive experience with the core task contributes substantially to satisfaction.

This satisfaction with one's role in surgery is clearly related to position: Junior residents were significantly less satisfied with the responsibility granted to them (3.86 on a scale from 1-5) than senior residents (4.42) and chiefs/consultants (4.79). A similar difference was found in the general questionnaire, where junior residents indicated significantly less satisfaction with training (e.g., training in medical specialization is well supported in our

ward), with a mean value of 3.18 on a five-point scale (chiefs/consultants: 4.0; senior residents: 3.81).

DISCUSSION

Main results and comparability to existing studies

Regarding daily tasks, we found that a little more than one fifth of the time (21.2%) was spent with tasks that are directly surgery related (i.e., surgery and preparation for surgery). Another fifth (21.7%) was directly patient-related; about ten per cent (10.4%) was spent in meetings and communicating about patients, and somewhat less than one fifth (18.6%) with documentation and administration. The remaining time was spent with teaching, research, leadership and management and not task-related activities.

There are few other studies that analyzed the workday routine of physicians working in hospitals, and only the study by Mache et al. [15] is reasonably similar to ours. Some other studies either had much fewer surgeons [16], or a much smaller amount of work time analyzed [17]. Mache et al. (2010) [15] observed 20 junior surgeons for a 60 work days, collecting 576 hours of data. To compare their results with the current study, we combined surgery and preparation for surgery into surgery-related tasks; consultation hours, ward rounds, patient related discussions and calls into individual patient work; reports and patient related conferences into meetings and team communication about patients; writing patient related records and administration into documentation and administration. As participants in Mache et al. all were junior residents, we compare their data with those from our junior residents. The junior surgeons in the study by Mache et al. spent somewhat more of their time (24.4%) with surgery- specific work, as compared to 17.34% for our junior surgeons. The percentage spent on individual patient work was comparable (Mache et al.: 21.69%; junior surgeons in our study: 23.64%), and so was the percentage of time spent for documentation and administration (Mache et al.: 25.28%; junior surgeons in our study: 25.67%), and for

teaching (Mache et al.: 1.97%; junior surgeons in our study: 1.93%). The only really large difference was observed for meetings and team communication about patients, which was 23.6% in the study by Mache et al. and 10.86% for the junior surgeons in our study. As the categories could not be matched exactly, these data suggest a reasonable convergence overall.

In terms of attractiveness, surgery was by far the most attractive task, confirming surgeons' passion for their core tasks [1,2]. Their core role is attractive to them, and this is true for all hierarchy levels; it therefore is not surprising that doing surgery is a source of satisfaction. However, it is not simply the amount of time spent with surgery that counts; it is experiencing surgery as positive and having the aspired responsibility during surgery that is associated with daily satisfaction. By contrast, writing patient reports and doing administrative work constitute the least attractive tasks, and the extent to which these tasks are considered illegitimate in the sense that they are not part of one's role and detract from medical tasks proper is associated with lower daily satisfaction.

Typically, when differences between positions occurred, they indicated lower satisfaction by junior residents. Junior residents spent more time writing patient reports and doing administrative work than the other groups, and they rated these tasks as less attractive than surgeons in other positions. Furthermore, they were less satisfied with the responsibility granted to them during surgery. This reduced responsibility may well be justified by their less advanced level of training; however, it may also reflect problems with training and coaching, which were rated as less satisfying by junior residents in the general questionnaire. However, it is also possible that the lower job satisfaction corresponds to the U-shaped association of job satisfaction with age. Job satisfaction has been found to decline in early career stages, followed by an increase later on ; more experienced physicians have been found to be more satisfied in several studies, possibly due to greater autonomy and responsibility, but also to lower private demands (e.g., small children) and greater skills in coping with high demands [18].

Regarding gender, there were not many significant differences, but those that did occur usually implied better values in terms of liking tasks and satisfaction for female surgeons. We have no immediate explanation for this finding.

Strengths and Limitations

There are several limitations of this study. First, all data are based on self-report, which entails the danger of common method bias. Using daily reports attenuates this bias, as they reduce the tendency to accommodate recalled events to pre-existing beliefs and attitudes. Furthermore, job satisfaction was not correlated with the amount of time spent in surgery but only with appreciation of surgery; this result indicates that participants did not let factual reports be colored by their attitudes but clearly distinguished between facts and their evaluation. Thus, although we cannot rule out a common method effect, it does not seem to strongly distort our results. A second limitation is the rather modest sample size. The fact that our results corresponded reasonably well with those of other studies is encouraging in this respect, but further research is needed on these issues.

Second, the sample size is not very high, especially when breaking down results by subgroups. On the other hand, diary data about hospital surgeons' workday are rare; responding to daily questionnaires is cumbersome, and motivating surgeons to participate is not easy. Typically, therefore, sample sizes in other studies that used a similar approach are lower than those in our study [15,16]. Results based on such sample sizes can only be considered suggestive; on the other hand, they provide detailed information that most other studies cannot provide.

Using single-item measures represents another limitation, as scales with more items would have been preferable. However, more items also increase the danger of people dropping out. Research has increasingly shown that single-item measures often are acceptable [19,20]; for instance, the validity of single items has repeatedly been shown for job satisfaction [21]. Considering the additional burden of many items and the corresponding

danger of people not participating or dropping out, it therefore seems justifiable to use single-item measures.

Using reports of daily activities over five days constitutes a strength of our study; it reduces method bias (see above), and it provides insights into daily tasks that are being carried out and into the attitudes of the surgeons concerning these activities.

CONCLUSIONS

Golder et al. [22] concluded for hospital doctors in general that they are highly motivated despite growing time and effort for administrative work; this conclusion can also be drawn for the hospital surgeons participating in our study.

The proportion of core tasks (i.e., surgery-related tasks) to other tasks, most notably administrative tasks, remains a concern. As Becker et al. [23] note, administrative tasks are associated with "the feeling that administrative requirements are nonmedical tasks and keep the doctors from doing their originally assigned work (p. 100)". Obviously, administrative tasks are found in any job. But as their proportion grows, they are increasingly perceived as illegitimate, and associated with lower satisfaction. Our results are in line with studies showing that illegitimate tasks are associated with various types of stress symptoms [24,14,25].

Possible consequences might relate to the way work is organized. Some of the tasks that physicians resented refer to work they should not have to do, such as spending a lot of time getting access to information that should be readily available; to organize beds for patients, etc. Some of these, such as dealing with insurance companies, might be taken over by specially trained nurses or administrative staff, and some tasks may simply be redundant [see 26]. A focus on reorganizing work in a way that reduces non-medical demands on physicians would reduce their work load, most notably potentially illegitimate tasks, and at

the same time increase the percentage of work that is related to their core role, which also are the tasks they like best.

It is striking that in most cases in which differences between positions occurred, it tended to be the junior residents who fared worst. In terms of tasks, they had to write the highest number of reports; they spent rather little time operating. In terms of attractiveness, they liked many tasks least (most notably writing rapports and doing administration), and they had the lowest values in satisfaction; these differences were not statistically significant for general daily satisfaction, but they were for satisfaction with the responsibility granted to them during surgery, and for training. Training issues were reported to be prominent in the study by Seelandt et al. [2]. It is difficult to judge to what degree this comparatively low satisfaction is fueled by unrealistic aspirations, for instance in terms of underestimating the time it takes to acquire expertise , and thus attributing slow progress to inadequate coaching and training opportunities. It is possible, however, that training in some hospitals is not planned and executed systematically enough and perhaps does not utilize newer training methods enough to ensure optimal training and coaching; [see 27].

Given the difficulties to attract medical students and residents to surgery [28], but at the same time the dedication for surgery work proper displayed by practicing surgeons [5], thinking about measures to increase the proportion of time spent doing surgery, to decrease the amount of administrative work, to optimize training and development for young surgeons, and thus to create conditions in which surgeons can find fulfillment through being involved in high quality surgery, is likely to benefit them as well as their patients.

DECLARATIONS

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Faculty of Human Sciences of the University of Bern (Protocol No 2012-6-140960). Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available from the first author or the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

FT, MUK, NKS and GB did the study conception and design. EH and MUK collected the data. EH and FT analyzed and interpreted the data. EH, FT and NKS drafted the manuscript. GB, MUK and NKS revised the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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2.4 Noise in the Operating Room

As mentioned in chapter 2.1, the list of potential distractors in the OR is a long one, with noise being one of them. There are multiple sources of intraoperative noise pollution in the OR. It can originate from technological devices like phones, clinical alarms, monitors, music devices (Thomas & Cammarata, 2017), surgical instruments, metal equipment, ventilation, as well as from behavioural sources like conversations, patient care activities, and staff entering and leaving the room (Commission, 2017). Therefore, operation rooms are noisy environments (Katz, 2015) with noise pollution levels that regularly exceed international recommendations for concentrated work (Healey, Primus, & Koutantji, 2007; Kam, Kam, & Thompson, 1994; Shankar, Malhotra, Ahuja, & Tandon, 2001).

Exposure to noise, defined as unwanted sound, has negative effects: it can lead to more exhaustion (Witterseh, Wyon, & Clausen, 2004), elicit stress responses (Basner et al., 2014; Rylander, 2004), impair sensorimotor performance (Szalma & Hancock, 2011), interfere with communication (Keller et al., 2016; Stansfeld & Matheson, 2003), and impair cognitive performance, for example through distraction (M. A. Baker & Holding, 1993).

There is evidence that noise affects surgical performance. Noise pollution was associated with higher levels of patient complications (Dholakia et al., 2015; Grayson et al., 2005; Kurmann et al., 2011). In a survey study, the majority of surgeons, anaesthetists, and OR nurses reported being disturbed by noise during surgeries (Tsiou, Efthymiatos, & Katostaras, 2008). Noise may impair performance because noise distracts and interferes with the ability to concentrate (Belojevic, Slepcevic, & Jakovljevic, 2001; Habibi, Dehghan, Dehkordy, & Maracy, 2013; Szalma & Hancock, 2011). In one study, the combination of noise and other stressors led to the highest performance impairments (Moorthy, Munz, Dosis, Bann, & Darzi, 2003). Thus, noise is most likely to have a negative impact on performance when task complexity is high (Loewen & Suedfeld, 1992). During surgeries, task complexity varies.

Not only does task complexity vary during surgery, but also the noise level itself. Several studies reported changes in noise levels during the surgery, usually with noise levels increasing during the course of the surgery (Ginsberg et al., 2013; Jenkins, Wilkinson, Akeroyd, & Broom, 2015; Kurmann et al., 2011).

Surgeries have different phases; the opening phase, the main phase, and the closing phase. Periods of high complexity differ in the surgical phases (Tsiou et al., 2008; Wadhera et al., 2010) and vary for the different OR personnel groups. For surgeons, the main phase of the surgery is the most complex phase and generates the highest cognitive workload (Parker, Flin, McKinley, & Yule, 2014). Since task complexity plays a role on how much impact noise has, and noise levels change during

surgeries, it is therefore important to measure not only overall noise, but also look at noise in the different surgical phases and how this affects the different team members.

That is why the aim of the study in the next chapter was to measure the noise difference in the separate phases and to examine this in relation to the different vulnerability levels of the various team members in the OR. The paper relates noise pollution levels in different phases of long open abdominal surgeries to reports of being distracted of main and second surgeons, anesthetists and scrub nurses.

2.5 Paper on Noise in the Operating Room

This chapter contains the paper on noise in the operating room with the title: “Noise in the Operating room distracts member of the surgical team. An observational study” which is published.

Keller, S., Tschan, F., Semmer, N. K., **Holzer**, E., Candinas, D., Brink, M., & Beldi, G. (2018). Noise in the Operating Room Distracts Members of the Surgical Team. An Observational Study. World journal of surgery, 1-8.

Noise in the Operating room distracts member of the surgical team.

An observational study

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Short title: Noise and reported distraction

Keywords: Noise, Distraction, surgery

Grant support: This work was supported by the Swiss National Science Foundation [grant # CR13I1_138273 and CR13I3_156882].

Conflict of interests: None of the Authors declares a conflict of interest

Word count: 2637

Abstract (193 words)

Background

Noise pollution in operation rooms (OR) may distract the surgical team members. Especially during phases of high task complexity, noise can jeopardize concentration. Phases of high complexity are related to task specificities and may thus be different for different members of the surgical team.

Study Design

Noise exposure was measured during 110 open abdominal surgeries. Distinguishing three phases (opening, main phase, and closing), noise was related to self-report of distraction levels by main and secondary surgeons, scrub nurses and anesthetists.

Results

Noise pollution was higher than recommended levels for concentrated work. Adjusted for duration, surgical type, and difficulty of the surgery, results showed that second surgeons are more likely distracted when noise pollution was high in the main phase; and anesthetists are more likely distracted when noise pollution was high during the closing phase. Main surgeons' and scrub nurses' concentration was not impaired by measured noise levels.

Conclusions

In phases with higher concentration demands, noise pollution was particularly distracting for second surgeons and anesthetist, corresponding to their specific task demands (anaesthetists) and experience (second surgeons). Reducing noise levels particularly in the main and closing phase of the surgery may reduce concentration impairments.

Keywords: **Noise; Distraction; Concentration; Phases of surgery**

Introduction

Operating Rooms (OR) are noisy environments [1] with noise pollution levels that regularly exceed the maximum of 55 dB(A) noise limit for task requiring high mental concentration [2-7]. High noise levels in the OR have various sources, from handling equipment to loud conversations [2, 8, 9], so many of the noise sources are controllable, to at least some extent [6].

Surgeons, anesthetists and OR nurses regularly report being disturbed by noise during surgeries [10]. Exposure to noise, defined as unwanted sound, has many negative effects: It can lead to exhaustion [11], elicit stress responses [12, 13], impair sensori-motor performance [14], interfere with communication [15], and impair cognitive performance [16]. There is evidence that noise negatively affects surgical performance. Noise pollution has been found to be associated with higher levels of patient complications [17-19], and higher error rates [20]. Higher noise levels also led to more irritation[21], impaired auditory performance [22] and impaired communication among members of the surgical team [23]. Nevertheless, experimental studies did not show performance impairments for manual tasks for surgeons exposed to different types and levels of noise [24, 25]. For anesthetists, negative effects of noise have also been found: Noise exposure impaired anesthetist's mental efficiency and short-term memory [26] and decreased their speed of response to patient changes [27].

Most of the empirical findings relating noise to surgical performance are based on short term experimental research. However, effects of noise may be different if performance has to be maintained over a long period of time under elevated noise levels [28] but also if additional stressors [20 22] are present or if task complexity is high [29]. During surgeries, task complexity varies across the opening phase, the main phase and the closure phase [10, 30]. For surgeons, the main phase of the surgery is the most complex phase and generates the highest cognitive workload [31], whereas for anesthetists, the closure phase is particularly demanding, because patient emergence is induced during this phase [31-33]. For OR nurses, attention demanding phases seem more fluctuant over the course of a surgery [34].

Aim of the study was to identify whether elevated noise levels in the OR in different phases of the surgical procedure were related to self-reported distraction of surgeons, anesthetists and scrub nurses.

Material and Methods

This prospective observational study took place in the visceral surgical department of a middle sized European University Hospital. It relates noise exposure measurements during surgeries with self-report of surgeons, anesthetists and scrub nurses obtained before leaving the OR.

Inclusion criteria were elective surgeries planned as open abdominal procedures with an expected duration of at least 60 minutes up to 7 hours (the limit of the sound meter recording capacity was 8 hours) and the availability of observers. Data were collected for 119 surgeries; nine surgeries were excluded because of technical problems with the sound meter (i.e. too long surgery), the final sample is 110 surgeries or a total sound measurement time of 367 hours. The local ethical board approved the study.

Noise (sound pressure levels), was measured with a digital sound level meter (TES-1352H; ©, TES Electrical Electronic Corp., Taipei, Taiwan, R.O.C.). A-weighted sound pressure levels (SPL) were recorded each second between incision and closure of the operative procedure. The sound meter was placed on the main operative lamp above the surgical team. Noise levels were calculated for each phase of the surgery.

Although measuring sound pressure level is relatively easy, it is more difficult to assess noise levels, because they fluctuate over time. A common measure of noise background for a given exposure time is the median noise level (L_{50}), which is the level of noise that is exceeded during 50 percent of exposure time. This measure has been used in previous OR related studies [9, 10]. We thus chose L_{50} to describe noise exposure, measuring noise levels exceeded in 50% of the duration of the respective phase for each surgery. In

contrast to other noise levels, for example the Leq (energetic average sound pressure level) the L_{50} metric has the advantage to be relatively insensitive to suddenly occurring high level noises that are not representative for the measurement period.

Phases of the surgery were distinguished based on the presence of the main surgeon [35], as his or her presence likely indicated a high complexity period. In the surgical department where the study took place, second surgeons (holding a general surgery degree and working towards a specialty degree) were the responsible surgeons for less complex periods. They often started the surgery until the target organs are ready for resection (*phase 1*). The main phase (*phase 2)* started when the main surgeon joined the team. Unless there were special events or requirements, the main surgeon left before closing; if this happened, the third, and final phase started *(phase 3).* In the case the main surgeon was present throughout the procedure, the whole surgery was considered to be phase 2. If the main surgeon was present from the beginning but left before closure, we coded no phase 1 for those surgeries. If the main surgeon joined for phase two and stayed to the end of the surgery, we coded no phase 3. Observers recorded the time of arrival and departure of the main surgeons.

Difficulty of surgery was assessed with one question, asking "How difficult was this surgery for you?" using a 1 to 7 scale with two opposite poles "*easy, routine"(1)* to *"very difficult" (7).*

Feeling distracted was the main outcome variable and was measured as the subjective self-reported distraction during the surgery. This was assessed with one question, using a 1 to 7 scale with two opposite poles: "During this surgery, I could work in a very *concentrated way (1)* to …I felt *very distracted (7)* and a midpoint descriptor of "medium".

Observers present during the surgery handed the questionnaire to surgeons, anaesthetists and nurses at the end of the surgery, or before they left the OR. Respondents were classified as distracted if they indicated a level of distraction of four (middle) or higher; they were classified as concentrated, if they indicated a level of distraction of three or less.

Statistical analyses were performed using SPSS® for Windows ® version 24 (IBM, Armonk, New York, USA), P <0.05 (two-tailed) was considered statistically significant; 95% confidence intervals are reported. The difference of noise levels across phases was tested with repeated measurement analysis of variance; pairwise comparisons were based on the Least Square Difference method. Influences of noise levels on self-reported distraction were assessed using univariate logistic regression for univariate effects and adjusted logistic regression for effects adjusted for difficulty, type of surgery as well as for duration of the phases.

Results

Sample characteristics:

The sample consisted of 110 surgeries (53 hepatobiliary surgeries, 19 upper gastro-intestinal tract surgeries, 26 lower gastro-intestinal tract surgeries, 12 other visceral surgeries; one surgery was not finished as planned, because it was terminated after a diagnostic laparoscopic procedure). Mean duration from incision to closure was 4.34h (SD = 1.65h); median = 4.27h; duration ranged between 1.2h and 7.3h.

Response rate for the distraction self-report was 91.8% for the main surgeons; 76.4% for the second surgeon; 95.5% for the anesthetists, and 96.4% for the scrub nurses. According to the cut-off criteria (at least 4/7), 38.6% of the main surgeons, 42.9% of the second surgeons, 16.2% of the anesthetists, and 11.3% of the scrub nurses felt distracted during the surgery (see Table 1).

In 91 of the 110 surgeries, the main surgeon joined the team only for the main phase. In 4 surgeries, the main surgeon was present throughout the surgery, in 13 surgeries, the main surgeon was present from the beginning, but left after the main phase; in 2 surgeries, the main surgeon joined for the main phase and stayed until the end of the surgery. Duration of the different phases and noise levels are reported in Table 2.

Noise level in different phases and types of surgery

Noise levels (L_{50}) were significantly higher in the main phase as compared to the first phase (t=-9.42, df 92. P<.001), and significantly higher in the closing phase as compared to the first phase (t=-7.990, df 86. P<.001), noise levels were not significantly different between the main phase and the closing phase (t=-1.899, df = 97, P=.060) (Table 2).

Noise levels between surgery types were not significantly different (Table 3), with one exception: In the main phase, hepatobiliary surgeries were significantly louder than lower GI-tract surgeries (P=.008).

Noise and reported distraction

Table 4 reports noise levels for "concentrated" vs "distracted" main surgeons, second surgeons, anesthetists, and scrub nurses across phases. Table 5 contains univariate results and results adjusted for duration of phase, surgery type (hepatobiliary vs other surgeries), and perceived difficulty of surgery for all phases, based on logistic regression analyses. The results show that noise levels did not affect self-reported distraction for main surgeons nor for scrub nurses in any phase of the surgery. For second surgeons, reported distraction was significantly related to higher noise levels, but only in the main phase, not in the first or the closing phase. Adjusting for phase duration, surgery type and perceived difficulty of surgery did not change these results. For anaesthetists, reported distraction was significantly related to higher noise levels only in the closing phase of the surgery, but not in the first and main phase. Adjusting for phase duration. type of surgery, and difficulty did not change this result. Figure 1 illustrate noise levels (a) for second surgeons reporting concentration versus distraction in the main phase and (b) for anaesthetists reporting concentration versus distraction in the closing phase.

Discussion

This study confirmed that noise pollution in the OR is a real concern. First, the recommendations for maximum noise levels of 55 dB(A) [5, 6] were exceeded in at least 50% of the time in the main and the closing phase. Other studies reported similar [10], or even higher noise pollution [4, 36] in the OR.

Second, noise levels were not stable across the different phases of the surgery, with the main and closing phases being noisier than the opening phase. This result corresponds to several previous studies that reported increasing noise levels during surgeries or a particularly high noise pollution in the last phase of a surgery [10, 17, 32, 33, 37]. This implies that noise pollution is highest in the phases of high mental workload for surgeons (main phase) and well as for anesthetists (in the closing phase) [30]. Surgeons, anesthetists and nurses reported distraction at the end of their presence in the OR. It is possible that they subjectively "averaged" distraction levels over the whole time they were present; it seems more likely, though, that their judgements were most strongly influenced by moments of especially high distraction. The results show that only noise in the main phase influenced second surgeons' reported distraction, and only noise in the last phase influenced anesthetists' reported distraction. This indicates that, noise pollution in high mental workload phases led to particularly high distraction.

In university hospitals, the main phase of the surgery may be particularly straining for second surgeons because they are in a training situation. This implies that they either learn how to perform the surgery by assisting the main surgeon, or, if already well trained, perform the surgery under close supervision. These factors can be additional stressors in the main phase. For anesthetists, emergence is one of the most complex tasks. For the rest of the surgical team, the last phase is often a routine phase and the team starts relaxing[38, 39]. To allow for concentrated work for the anesthetists during this phase, the suggestion of a "sterile cockpit" period - a period that is explicitly declared as high workload during which

distractions should be limited – has already been discussed [30, 32, 33, 40]. Anesthetists have to react to patient changes rapidly, and rely on auditory sources (such as pitch changes in surveillance sounds, as well as auditory alarms) [27]. Therefore, anesthetists cannot use a strategy of blocking out noises to protect themselves from noise pollution.

Neither the assessment of distractions of scrub nurses nor the main surgeons were related to noise levels. A study in cardiac surgery has shown that for scrub nurses, none of the three intraoperative phases was characterized by very high mental workload, if no extraordinary events occurred – the highest mental workload of scrub nurses was during the preparation of the surgery [30]. This could also be the case for general surgery, as scrub nurses reported the lowest level of difficulty among all members of the surgical team.

Main surgeons reported over 70% of surgeries as being difficult, confirming high difficulty in the main phase. Despite the high mental workload, main surgeons may not report higher levels of distractions because of their high experience. Previous studies found indeed that experienced, but not inexperienced, surgeons are able to block out distractors [24], and studies investigating the effect of distractors other than noise revealed that experienced surgeons showed no or few performance impairments under distracting conditions [25, 41]. However, this does not mean that surgeons are totally oblivious to noise distractions – in another study, almost 60% of surgeons reported that loud noises disturb them [10]. In the present study, main surgeons were not exposed to OR noise as long as second surgeons and we also cannot exclude that they may not suffer cumulative effects of noise over time.

A strength of this study is that noise measures and feelings of being distracted were assessed in the same surgery and thus could be directly related to each other. Previous studies assessed subjective noise annoyance or objective noise measures, but did not combine them. Note that we did not ask whether participants were distracted by noise, but asked about a general feeling of being distracted. Thus, the answers are most likely not biased by the knowledge that noise influences concentration.

A limitation of the study is that only duration, surgery type and difficulty of the surgery were included as potentially confounding variables. It cannot be excluded that noise as well as reported distraction were influenced by third, unmeasured variables. It was also not possible to assess the sources of noise and thus to be able to distinguish between distractions related to the task, and off-task distractions [42] – these might have different impacts on concentration. We also could not measure surgical performance in this study. A limitation is also that we measured concentration – distraction with a single item, which does not allow to capture the concept in a fine-grained way. Finally, the definition of phases on the basis of the main surgeon being present may not fully correspond to the complexity of tasks demands; for instance, the main surgeon might stay during periods of lower complexity for reasons of teaching. However, other definitions of phases (e.g., based on time) would entail similar problems, and a definition based directly on complexity was beyond the expertise of the observers. Note, however, that the presence of the main surgeon during less complex periods would lead to an underestimation of the effects of complexity, and therefore is not likely to invalidate our results.

Many noises in the OR stem from technical devices used [10, 37], suggesting that the design of OR material may contribute to prevent noise pollution. Another source of noise is behavior. Note, however, that general "rules of silences" are not very likely to be successful for reducing noise during long surgeries; rather, periods of "silence" should alternate with well-timed periods of relaxing and chatting, which may help energize the team and maintain a good climate and high morale.

Noise reduction is one of the key safety design principles recommended in healthcare [43]. Noise reduction programs in hospitals in general [44], and in OR's [6], showed that mean reductions of 3 to 5 decibel (dB) can be achieved. Note that an increase of 3 dB represents doubling the acoustic energy, and an increase of 6 dB is perceived as 50% increase in volume [45], so noise reductions of even a few dB are already worthwhile.

Acknowledgements

Dr. Anita Kurmann, a scientific advisor for this study, deceased August, 7th, 2015. We thank Julia Seelandt for her help in organization of data collection and data collection; Anna Püschel, Moana Monnier and Nadja Jenni for their contribution to data collection; Uwe Klopsch (technician) and Brigitte Dubach (head nurse) for their technical and organizational support.

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Tables and Figures

Table 1 Descriptive statistics for self-reported feeling of being distracted and difficulty of surgery for main and second surgeons, scrub nurses and anesthetists

	n	Mean	Standard Deviation	Range (min, max)	
Feeling distracted					% distracted (≥ 4)
Main surgeon	101	3.12	1.47	1,6	35.5%
Second surgeon	84	2.79	1.45	1,6	32.7%
Anaesthetists	106	2.11	1.01	1,7	16.2%
Scrub nurses	105	2.40	1.01	1,7	11.3%
Perceived difficulty of surgery					% difficult (≥ 4)
Main surgeon	101	4.54	4.48	1,7	71.8%
Second surgeon	84	4.49	4.52	1,7	57.3%
Anaesthetists	106	3.98	1.40	1,7	67.6%
Scrub nurses	105	3.39	4.69	1,7	42.7%

Note: Feeling distracted and difficulty are reported on a scale from 1 to 7

Table 2 Duration and noise levels (L50) for different phases of surgeries

	N	mean duration [h]	SD duration [h]	95% CI lower	95% CI higher	L50 [db(A)]	SD [db(A)]	95% CI lower	95% CI higher
Phase 1: Preparation	93	1.17	0.776	1.01	1.32	54.52	1.55	54.21	54.84
Main phase	110	2.45	1.49	2.38	2.94	55.84	1.73	55.51	56.16
Phase 3: Finishing and closing	104	0.81	0.69	0.68	0.95	56.34	1.93	55.96	56.34

Table 3 Type of surgery, and mean noise level (L_{50}) in different phases

Surgery type	Upper GI tract		Hepatobiliary		Lower GI tract		Other	
	M	95% CI	M	95% CI	M	95% CI	M	95% CI
Phase 1 noise level [dB(A)]	54.49	(53.76 -55.23)	54.88	(54.44 -55.32)	53.79	(53.1 -54.49)	54.39	(53.24 -55.54)
Main phase noise level [dB(A)]	56.00	(55.25 -56.75)	56.30	(55.83 -56.76)	55.21	(54.56 -55.86)	55.44	(54.45 -56.42)
Phase 3 noise level [dB(A)]	56.69	(55.8 -57.59)	56.22	(55.67 -56.77)	56.38	(55.56 -57.21)	56.85	(55.59 -58.11)

Note: Noise level is expressed in L_{50} for each phase, M refers to the arithmetic mean of the L_{50} values

Table 4 Noise level across phases for main and second surgeons, anaesthetists, and scrub nurses reporting low vs high distraction levels

Target	Main surgeons		Second surgeons		Anaesthetists		Scrub nurses	
	concentrated	distracted	concentrated	distracted	concentrated	distracted	concentrated	distracted
Phase 1 L_{50} noise level [dB(A)]	-[a]	-[a]	54.05 (1.63)	54.47 (1.13)	54.51 (1.40)	54.27 (1.72)	54.59 (1.41)	54.31 (1.79)
Main phase L_{50} noise level	55.88 (1.62)	55.85 (1.86)	55.34 (1.64)	56.20 (1.42)	55.82 (1.74)	56.09 (1.52)	55.86 (1.68)	55.71 (1.91)
Phase 3 L_{50} noise level	-[a]	-[a]	56.20 (1.83)	56.38 (2.00)	56.14 (1.85)	57.20 (1.90)	56.36 (1.93)	56.05 (1.41)

Note: distracted: ≥ 4 on a scale from 1 to 7. Numbers in brackets are standard deviations

[a]Main surgeon is not present in this phase

Table 5 Relationship of noise level and reported distraction; univariate and adjusted for type of surgery, duration of surgery and self-reported difficulty

	Main surgeons		Second surgeons		Anesthetists		Scrub nurses	
	univariate OR; 95% CI; P	adjusted OR; 95% CI; P	univariate OR; 95% CI; P	adjusted OR; 95% CI; P	univariate OR; 95% CI; P	adjusted OR; 95% CI; P	univariate OR; 95% CI; P	adjusted OR; 95% CI; P
Phase 1 distracted	-[a]	-[a]	1.26 (0.915-1.77); 0.169	1.29 (0.90-1.86; 0.582	0.90 (0.610-1.339); 0.616	0.73(0.16-1.15); 0.220	0.93 (0.59-1.46); 0.745	0.96 (0.57-1.61): 0.875
Main phase distracted	0.989 (0.78-1.25); 0.924	0.927 (0.71-1.21); 0.537	1.476 (1.07-2.03); 0.017*	1.46 (1.06-2.01); 0.020*	1.108 (0.81-1.52); 0.522	0.986 (0.70-1.39); 0.933	0.951 (0.67-1.35); 0.782	0.911 (0.63-1.31); 0.616
Phase 3 distracted	-[a]	-[a]	1.068 (0.84-1.36); 0.588	1.082 (0.85-1.38); 0.528	1.367 (1.02-1.83); 0.036*	1.39 (1.01-1.92); 0.045*	0.922 (0.66-1.29); 0.638	0.772 (0.52-1.14); 0.194

Note: OR: Odds Ratio; * P < 0.05; 95% CI: 95% Confidence interval: -[a] Main surgeons were not present in this phase

Figure 1a: Boxplot illustration of noise level for second surgeons reporting being able to work concentrated or being distracted in phase 2.
Figure 1b: Boxplot illustration of noise level for anaesthetists reporting being able to work concentrated or being distracted in phase 3.

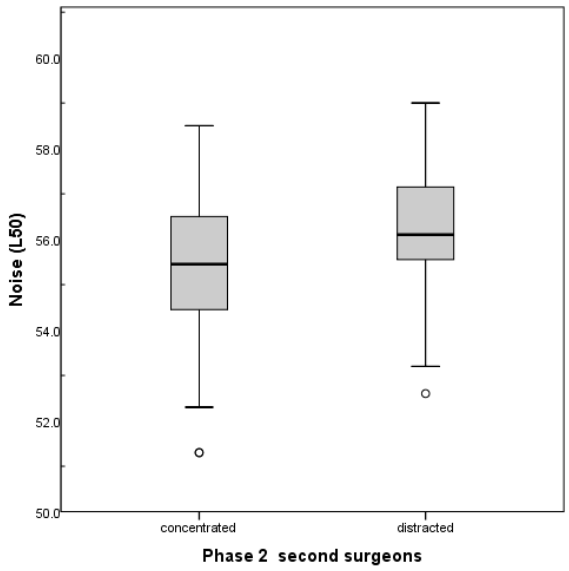

Figure 1a (second surgeons)

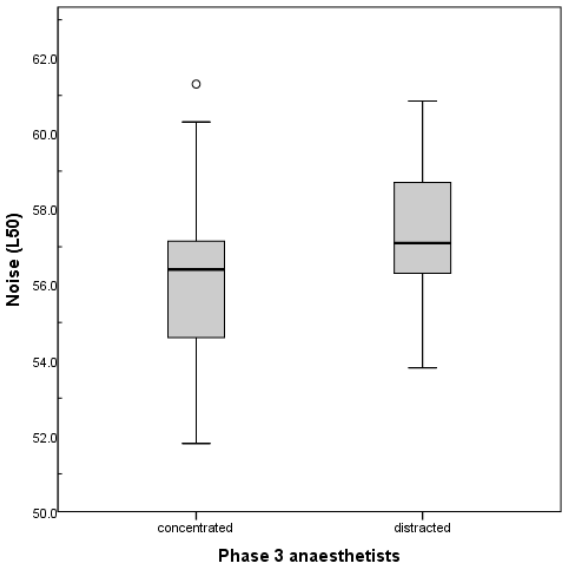

Figure 1b (anaesthetists)

2.6 Case-irrelevant Communication in the Operation Room

Communication is required in the operation room to coordinate the different health professionals involved in the surgery process (Jochum, 2017). Communication within surgical teams during the procedure can be related to the actual case (case-relevant communication) or it can be case-irrelevant. I will emphasize the importance of case-relevant communication in a later chapter of this thesis (chapter 3.1).

Case-irrelevant communication is defined very generally as "any conversation" irrelevant to the case (Healey, Olsen, Davis, & Vincent, 2008; Sevdalis, Healey, & Vincent, 2007). Because case-irrelevant communication is not necessary useful for the task at hand, it is generally seen as a "communication problem" (Weldon, Korkiakangas, Bezemer, & Kneebone, 2013) and it is often studied together with other distractors (Healey et al., 2007; Healey, Sevdalis, & Vincent, 2006).

By focussing on case-irrelevant communication as distractor, two important aspects are often neglected; its interpersonal function, and its detailed content.

Small talk can relax the atmosphere within the surgical team and release tension. A positive interpersonal climate is important for good teamwork (Nembhard & Edmondson, 2006) and it is beneficial in surgical teams (Nurok et al., 2011; Nurok, Lipsitz, Satwicz, Kelly, & Frankel, 2010). Strengthening the social bond in the team may facilitate open communication (Wang, Doucet, Waller, Sanders, & Phillips, 2016), which plays an important role in team effectiveness (Mesmer-Magnus & DeChurch, 2009) and contributes to more patient safety (Okuyama, Wagner, & Bijnen, 2014).

In addition, case-irrelevant communication is not only small talk. It can be related to other aspects of work, like communication about other patients or organizational issues, that can be functional (Jothiraj, Howland-Harris, Evley, & Moppett, 2013). A previous study showed that only half of the observed case-irrelevant communication were small-talk, whereas 25% were related to other patients (Sevdalis et al., 2007).

In sum, case-irrelevant communication may distract from work, but case-irrelevant communication may also have important functions for work organization at large, and a positive social function for the surgical team. One step in assessing those different functions of case-irrelevant communication, is to analyze its content. In knowing the content, there may be a possibility to pin down when case-irrelevant communication is a distractor and when it is beneficial. Therefore, the paper in the following chapter will evaluate the content of case-irrelevant communication during elective surgical procedures.

2.7 Paper on Case-irrelevant Communication within the OR team

This chapter contains the paper on case-irrelevant communication in the operating room with the title: “More than talking about the weekend: content of case-irrelevant communication within the OR team” which is published.

Widmer, L. W., Keller, S., Tschan, F., Semmer, N. K., **Holzer**, E., Candinas, D., & Beldi, G. (2018). More than talking about the weekend: content of case-irrelevant communication within the OR team. World journal of surgery, 42(7), 2011-2017.

More than talking about the weekend: content of case-irrelevant communication within the OR team

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Running head: More than small talk

Keywords; case-irrelevant communication; distractions; patient safety

Grant support: Swiss National Science Foundation Grant # CR13I1_138273 and CR13I3_156882, Swiss National Competence Center of Affective Sciences

Conflict of interest: None of the authors declares a conflict of interest

Acknowledgements

We thank Christina Gfeller, Simon Huber, Nadja Jenni, Franziska Leupi, Moana Monnier, and Julia Seelandt for their help in data collection; Mina Dimitrova for help in coding; Uwe Klopsch for technical assistance; Brigitte Dubach (head nurse) for her support.

Manuscript word count: (2465)

Abstract (250 words)

Background: Case-irrelevant communication (CIC) is defined as “any conversation” irrelevant to the case. It includes small talk, but also communication related to other work issues besides the actual task. CIC during surgeries is generally seen as distracting, despite a lack of knowledge about the content of CIC and its regulation in terms of adjustments to the situation of CIC. Primary goal of the study was to evaluate CIC content; secondary goal was to evaluate whether surgical teams regulate CIC according to different concentration demands of surgical procedures.

Methods: In 125 surgeries, 1396 CIC events were observed. CIC were content coded into work-related CIC (pertaining to other tasks or work in general) and social CIC (pertaining to acquaintance talk, gossip, or private conversation). The impact of different phases and the difficulty of the surgical procedure on CIC were assessed.

Results: Work-related CIC were significantly more frequent (2.49 per hour, SD = 2.17) than social CIC (1.42 per hour, SD = 2.17). Across phases, frequency of work-related CIC was constant, whereas social CIC increased significantly across phases. In surgeries assessed as highly difficult by the surgeons, social CIC were observed at a lower frequency, and less work-related CIC were observed during the main phase compared to surgeries assessed as less difficult.

Conclusion: The high proportion of work-related CIC indicates that surgical teams deal with other tasks during surgeries. Surgical teams adapt CIC according to the demands of the procedure. Hospital policies should support these adaptations rather than attempt to suppress CIC entirely.

Introduction

Performing surgery is a complex task that requires high concentration. However, interruptions and distractions that may threaten this concentration are frequently observed during surgeries

[1-4]. A potential distractor is case-irrelevant communication, which is the focus of this study. In particular, this study aims to describe (1) type and frequency of case-irrelevant communication and (2), the regulation of case-irrelevant communication within the surgical team.

Communication within a surgical team during the procedure can be related to the actual case (case-relevant communication) or it can be case-irrelevant (CIC). CIC is defined very generally as "any conversation" irrelevant to the case and may include small talk, but also communication related to other work issues besides the actual task (e.g. discussions about other patients; scheduling of other procedures)[5, 6].

Because CIC is not necessary or useful for the task at hand, it is often seen as a "communication problem" that needs to be dealt with in the operating room, and is studied together with other distractors[7]. Compared to other distractor categories such as door openings or noise events, CIC is more frequently observed during the intraoperative or early postoperative phases [2, 3, 6, 8-14]. Frequencies of CIC range from about every 20 minutes in shorter (< 4h) [12] to every 10 minutes in long open abdominal procedures [15].

Because the surgical team is involved in generating CIC, it potentially binds more attention of the surgical team than other distractors. Thus, CIC could be particularly harmful for concentration [3, 12]. Although surgeons report less concentration if more CICs are observed, recent reports show that the distracting potential of CIC is in the medium range and distracts less than issues involving technical equipment or procedural problems [8, 13]. A recent study suggests that the distracting potential of overall CIC is highly dependent on the context within the procedure, as CIC impacts on clinical outcome only when frequent during the closing phase of the surgery [15].

Despite its potential to distract, CIC may exhibit important other, even positive, functions. First, CIC related to other aspects of work may be required to solve other problems that typically occur simultaneously to surgeries in clinical practice, such as responding to

questions about other patients, or organizational issues [16]. Indeed, 25% of observed CIC have been found to be related to other patients [6]. A second important function of CIC may be social. Small talk can relax the atmosphere within the surgical team and release tension, and thereby be important for good teamwork[17-19]. Thus, CIC may contribute to a good social climate, and may be a sign of transformational leadership, a form of leadership which is advantageous in the OR [20].

Regulation of CIC within the surgical team is likely to be highly complex. Most of CIC is initiated by surgeons [2, 6, 13], and it is almost always targeted at other surgeons [6]. CIC can in general be controlled by the surgical team, e.g. by avoiding CIC when the concentration demands of the tasks are high[9, 21]. This type of regulation is analogous to talking to a passenger while driving: Although the distracting potential of conversations with passengers has been shown, drivers as well as passengers react to changes in driving conditions by limiting their conversations in heavy traffic [22]. It is thus reasonable to expect surgeons to engage less in CIC in phases of the procedure when high concentration is needed; as has been observed for other distractors [23]. The middle phase of a surgical procedure has been shown to be associated with the highest difficulty, whereas early or late phases (opening and closure) typically are less challenging [12, 13, 24]. One can thus expect that surgical teams regulate CIC specifically in the middle or very difficult phases of a surgical procedure.

In sum, CIC during surgery may be necessary, helpful or distracting. However, neither the content CIC nor the regulation of CIC within the surgical team has been explored in detail. Therefore, the primary goal of the current study is to explore the content of CIC during elective surgical procedures, and the secondary goal is to investigate the regulation of CIC within the surgical team across different phases of surgical procedures of different complexity.

Material and Methods

Inclusion criteria for observations were open abdominal procedures with an expected duration of at least one hour and the availability of observers. A total of 193 procedures were observed in a European University hospital. In one surgery, no CIC was observed. Sixty-seven surgeries had to be excluded because the observers could not determine CIC-content precisely enough (e.g. because team members talked at a very low voice) for more than 70% of the CIC. The final sample consists of 125 procedures (Figure 1), performed by 20 different main surgeons.

The internal institutional review board agreed to the observation of the surgical teams. Individuals were consented with an opt-out procedure, as each member of the team could at any moment ask the observational team to leave.

Observation and Content Coding of CIC

Each surgery was observed by trained observers (work and organizational psychologists), using a validated event-based observational system [25]. The observation period was between skin incision and end of skin closure. The observers were seated in about 1.5m distance from the operating table, opposite to the lead surgeon. The observers coded each verbal exchange within the sterile team and between at least one member of the sterile team and the anesthesiologists. CIC was coded if the surgical team engaged in topics that were not related to the patient or the procedure.

If the team engaged in a CIC, the observers first noted that the CIC took place; the time was automatically recorded. If the observers could understand the content of CIC, they summarized it in the comment section of the coding application. Each observational comment was then content coded [26] into two main categories (related to work vs. small talk) with three distinct sub-categories each, according to the following description.

Main category **work-related CIC**:

1. *Other tasks or patients*. Examples are a conversation about an assistant physician who was asked to help out in a surgery in another OR, or a conversation about the next patient or a patient in the emergency room.
2. *Work and medicine in general.* Examples are a conversation about reducing the number of instruments that are required during operations; the surgeons discussing how to avoid back problems while doing surgery.
3. *Context talk related to the surgery* included comments about the context of the current surgery or its organizational aspects. Examples are the general quality of technical devices; the student asking for permission to leave and explaining the reasons.

Main category **social CIC (small talk):**

4. *Acquaintance talk* included introducing new collaborators and talking about one's own biography. Examples are that the surgeon asks the student to repeat her name and asks how long she will stay in the service; a surgeon talks about his work biography.
5. *Gossip* includes exchanging information about other people. Examples are talking about opinions of a colleague not present, talk about hospital policies.
6. *Private conversations* include talking about one's own personal life (excluding professional biography). Examples include talking about one's children or pets; talking about a recent popular vote.

If a conversation involved several categories, the most predominant category was coded, so that each CIC represents only one category. CICs that could not be categorized were noted. For validation purposes, two coders independently categorized 22% of the comments. Inter-observer agreement (Cohen's weighted kappa) was 0.76, which indicates good inter-observer reliability: the rest of the comments were coded by the first author [27].

Case-related communication

Case-related communication was coded if the surgical team engaged in topics related to the patient or the procedure, including case-related teaching and leadership[25].

Difficulty of Surgery

After each surgery, just before leaving the operation room, the surgeons completed a short standardized questionnaire to evaluate the difficulty of the operation. Difficulty was assessed with the question "How difficult was the surgery for you?" and assessed on a 7-point Likert type scale with scores between 1 (very easy) to 7 (very difficult). If more than one surgeon was present, their difficulty assessments were averaged. Difficulty levels were split at the mean (4.5) in low and high difficult procedures; thus, 49.6% of the surgeries were categorized as low difficulty. Questionnaires were confidential.

Phase of Surgery

Three different phases of the surgery were distinguished according to the presence of the main, and most experienced, (senior) surgeon [28, 29]. In 102 of the 125 surgeries, the senior surgeon joined the team after the preparatory phase, stayed for the main phase, and left the surgery before the closing phase, this is customary in this institution, where fellows with board examination often are responsible for the first and last part of the procedure. The main phase can be considered the most difficult part of the surgery [29]. All surgical steps during this period were either performed or were closely supervised by the senior surgeon. Thus, phases were defined as follows:

phase 1: before the senior surgeon is present

phase 2: senior surgeon present

phase 3: senior surgeon left the operation

Outcome Parameters

The primary outcome of the study was the frequency of content of CIC, according to the main and sub-categories. The secondary outcome was the content of CIC of the two main categories for easy and difficult surgeries across the three phases.

Statistical Analyses

For statistical analysis we used SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Macintosh, Version 24.0. Armonk, NY: IBM Corp.). Non-parametrical data are displayed as median and inter-quartile range (IQR), parametrical data as mean and standard deviation (SD). Inter-rater agreement was assessed using Cohen's weighted Kappa statistics. A P-value below 0.05 was defined as statistical significant. Mann-Whitney U test were used for comparisons, T-tests for repeated measures and analyses of variances for repeated measures were used to compare CIC across and phases. Post hoc comparisons were Bonferroni corrected.

Results

Frequency of CIC

In the 125 surgeries included (Table 1), 1396 CICs were observed; with a mean of 11.17 per surgery (SD = 8.79), a range of 1 to 48 per surgery, and a density of 2.97 CIC (SD=3.50) per hour of surgery. Work-related CICs were observed at a frequency of 2.49 observations per hour with a standard deviation (SD) of 2.17, social CIC were observed at 1.42 (SD 2.17) per hour ($P < 0.001$). During procedures, the frequency of overall work-related CIC did not change significantly; however, the frequency of social CIC was significantly higher in the last phase (Table 2 and Figure 2A and 2B). CIC amounted to 12.89% (SD = 10.13%) of all observed communication within the sterile team.

Regulation of CIC

We tested whether the surgical teams regulated the frequency of CIC according to the difficulty of the procedure and the phase. The frequency of work-related CIC was not

different for low and high difficult surgeries overall. However, in phase 2, significantly less work-related CIC was observed in difficult surgeries (Table 3). The frequency of social CIC was significantly lower in difficult surgeries than in less difficult surgeries. However, there was no statistically significant difference within the three phases of the surgery (Table 3).

Discussion

The study showed that CIC could be clearly distinguished in work-related CIC and social CIC. Overall, CIC did not occur very frequently, with about 2.5 work-related CIC and 1.4 social CIC per hour; only about 13 percent of all communication was CIC. Work-related CIC occurred more frequently, but overall, remained constant across procedures, whereas social CIC density significantly increased throughout a procedure. Within work-related CIC, conversations related to the context of the surgery were most prevalent.

The presence of the senior surgeon critically influenced the frequency of work CIC related to other tasks/patients and general topics, as these were more often observed in the main operating phase with the most senior surgeon present. This may be the consequence of different positions within the hierarchical structure: The most senior surgeon may more often address specific organisational questions than more junior surgeons. The potential negative, distracting aspect of work-related CIC may be attenuated, because during difficult surgeries, the surgical teams engaged in significantly less work-related CIC during the second, the main phase. This indicates that the teams regulated work-related CIC according to varying concentration requirements.

The frequency of social CIC in general was highest during the last phase of the surgery, after the senior surgeon had left. This increase is mainly due to private conversations. The increase may represent a more relaxed social climate after the most difficult main phase – although it cannot be excluded that the effect is simply due to the fact that the senior surgeon has left. As social CIC implies rather low concentration demands[30], it could also be that

fatigue after long operations contributed to the increase of social CIC. In that case, CIC may represent a surrogate parameter for decreasing concentration of the team. Overall, but not across phases, the surgical team engages in less social CIC in difficult surgeries. This, again, shows that the surgical teams adapted to the higher concentration demands in difficult surgeries.

Overall, the results show that if surgical teams do not communicate about the patient or the surgery at hand, they more often engage in work-related CIC than in social CIC. This indicates that they are dealing during surgeries with other work-related aspects during surgeries. Although work-related CIC may be a distractor for the surgery at hand, it may be functional for the other tasks surgeons have to do outside of the OR.

Social CIC may be good for social aspects, but questionable with regard to patient outcomes, as a previous study shown [15]. Again, surgical teams regulate social CIC if concentration demands are high. Given these and previous findings, we propose that social CIC need to be assessed specifically in future studies in order to identify any potential impact on concentration and quality, but also on patient outcomes.

The results of this study do not support a recommendation for changes in general policies in the operating room with regard to CIC [8, 31]. Both work and social CIC seem to be at least partially functional and should neither be avoided nor completely suppressed. Work CIC may be necessary for the coordination of work beyond the actual surgery and social CIC are may be good for group climate [12]. However, CIC should be regulated in accordance with the concentration demands of the situation.

As a conclusion, CIC is more diverse than simple small talk and should be distinguished in work-related and social CIC. Variations of CIC throughout the phases of surgery and according to the difficulty of the surgery indicate that the surgical teams adapt their CIC activity to the task at hand. Policies should support these natural adaptations rather than attempt to suppress CIC.

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Tables and Figures

Table 1 – Operative procedures and descriptive statistics

	(n=125)
Patient age (SD)	61.5(14.8)
Duration of surgery in hours (SD)	4.5(2.0)
Patient gender (% males)	68(55.9%)
Type of surgery	
hepatobiliary /pancreatic	63(50.4%)
Upper GI Tract	24(19.2%)
Lower GI Tract	22(17.6%)
Other	16(12.8%)
Average surgeon's evaluation of difficulty level (range 1-7, SD)	4.48(1.05)
Proportion CIC content coded (SD)	88.9%(10.4)

SD = Standard Deviation;

Table 2 – Content categories of CIC overall, and in phase 1, 2 or 3 respectively

	Overall mean(SD)/per hour N=125	min-max/per hour
Work-related CIC	2.49(2.17)	0-14.7
Other tasks/patients	0.70(0.95)	0-8.3
Work/medicine in general	0.44(0.78)	0-6.0
Context of surgery	1.34(1.11)	0-5.4
Social CIC (small talk)	1.42(2.17)	0-20.2
Acquaintance talk	0.13(0.23)	0-1.0
Gossip	0.26(0.48)	0-2.4
Private conversations	1.02(2.01)	0-20.2

	Phase 1 mean(SD) / per hour n=102	Phase2 mean(SD) / per hour	Phase 3 mean(SD) / per hour	P value (phases)
Work-related CIC	2.09(2.97)$_a$	2.40(2.29)$_a$	2.35(3.09)$_a$	0.618
Other tasks/patients	0.41(0.80)$_a$	0.76(0.86)$_b$	0.58(1.27)$_{a,b}$	**0.028**
Work/medicine in general	0.18(0.83)$_a$	0.47(1.01)$_b$	0.41(0.86)$_c$	**0.029**
Context of surgery	1.51(2.68)$_a$	1.18(1.32)$_a$	1.35(2.37)$_a$	0.517
Social CIC (small talk)	0.89(1.52)$_a$	1.02(1.25)$_a$	1.86(3.83)$_b$	**0.005**
Acquaintance talk	0.14(0.42)$_a$	0.07(0.18)$_a$	0.17(0.60)$_a$	0.27
Gossip	0.15(0.41)$_a$	0.20(0.43)$_a$	0.39(1.33)$_a$	0.1
Private conversations	0.28(1.17)$_a$	0.75(0.97)$_{a,b}$	1.20(3.45)$_b$	**0.038**

Phases with different subscripts were significantly different from each other (across rows, Bonferroni-corrected post-hoc tests)

Table 3: Work-related and social CIC across phases for surgeries with high and low difficulty ratings

	difficulty level	phase 1 before senior surgeon arrives	phase 2 senior surgeon present	phase 3 after senior surgeon leaves	overall
		Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Work related CIC	low	1.42 (3.05)	2.22 (2.45)	1.42 (5.40)	2.37 (2.20)
	high	1.23 (3.08)	1.39 (1.80)	1.39 (3.03)	1.93 (1.54)
	P[a]	0.634	**0.023**	0.854	0.080
Social CIC	low	0 (1.51)	0.8 (1.93)	0.87 (2.69)	1.18(1.76)
	high	0(0.99)	0.61(1.12)	0.68 (1.77)	0.73 (1.19)
	P[a]	0.42	0.24	0.414	**0.023**

IQR = interquartile range, a) P-values are based on M-W nonparametric tests

Fig.1 Flowchart

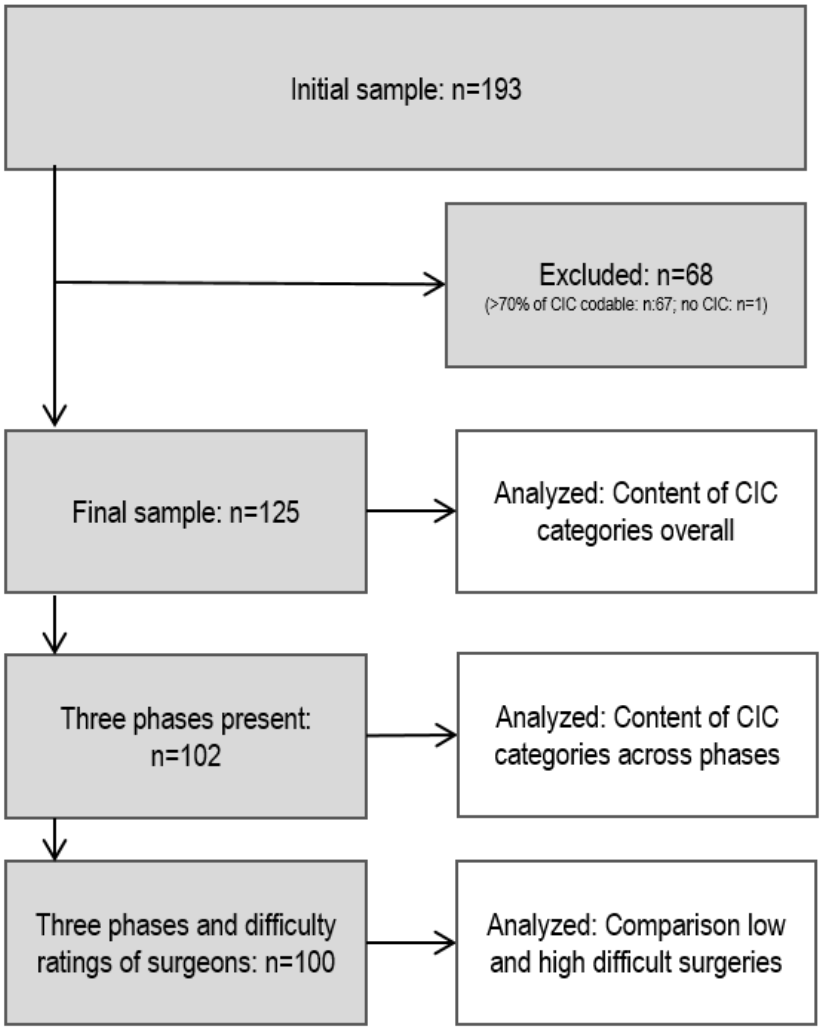
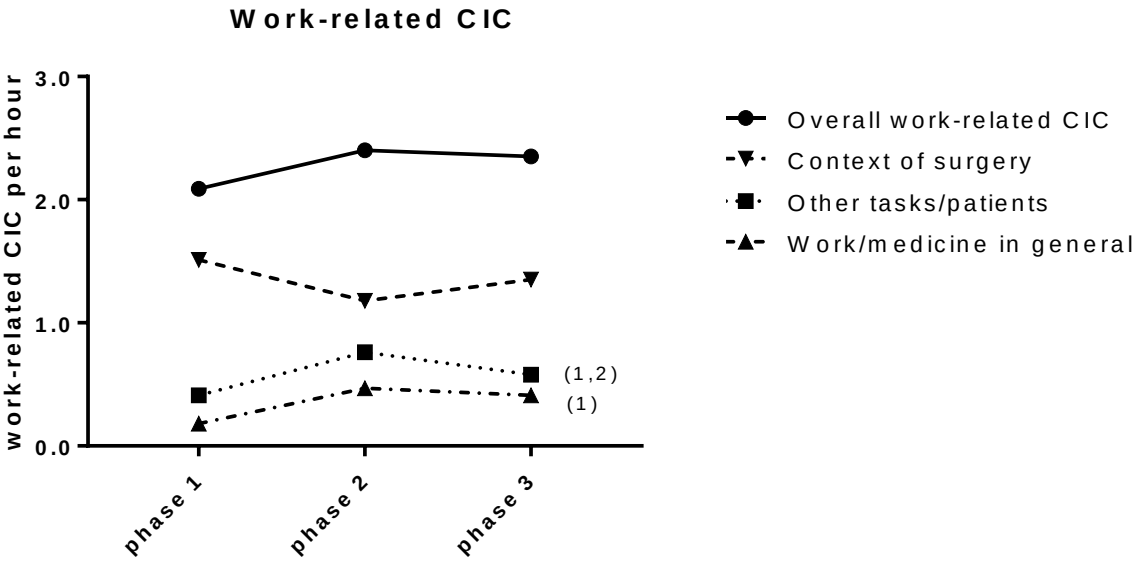
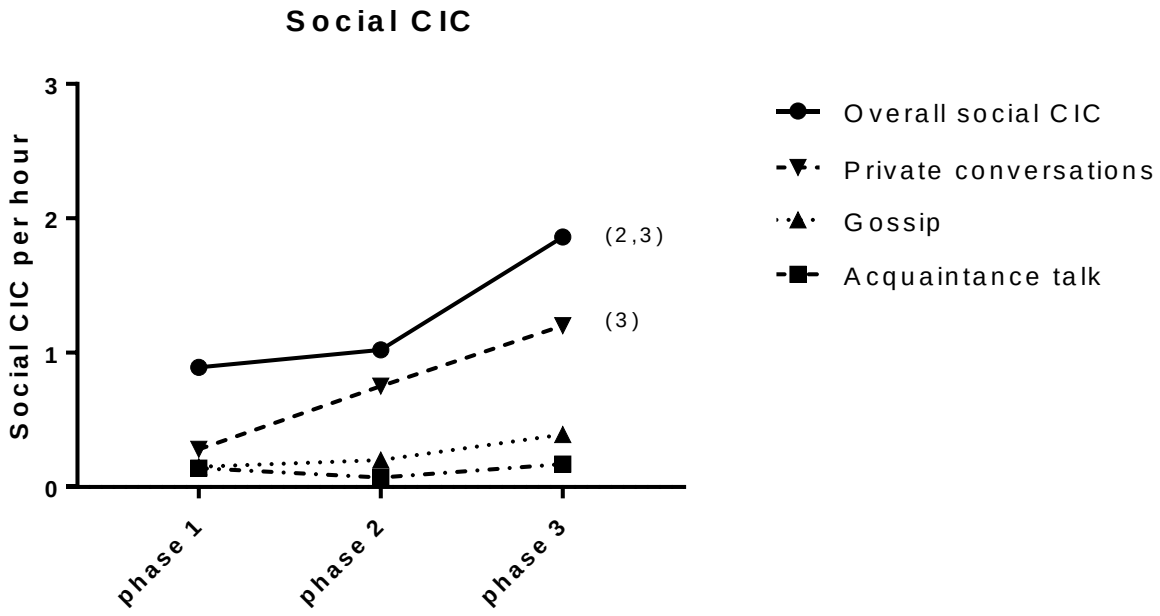


Fig. 2A Frequency of work-related CIC across phases



Legend Figure 2A
(1) significant difference between phase 1 and phase 2
(2) significant difference between phase 2 and phase 3

Fig. 2B Frequency of social CIC across phases



Legend Figure 2B
(1) significant difference between phase 1 and phase 2
(2) significant difference between phase 2 and phase 3
(3) significant difference between phase 1 and phase 3

3. Introduction of an intraoperative Briefing in the Operating Room

In the centre of the second part of this thesis is the StOP? Intervention. The intervention consists of introducing an intraoperative briefing (the StOP? protocol) in the OR. To embed the concept behind the StOP? protocol into its respective background, I first give a short introduction to the overall topic of teamwork and communication in the OR (chapter 3.1) and then elaborate on the topic of briefings in the OR (chapter 3.2).

Since all the manuscripts in this second part of this thesis are based on analyses surrounding the StOP? Intervention, the manuscripts have many overlaps concerning their topics. Therefore, I decided on a slightly different structure for this part. Instead of one chapter before each manuscript, there is only one chapter giving specific background and additional information to all four manuscripts.

3.1 Teamwork and Communication in the Operating Room

In the first half of this dissertation, I described possible causes of stress in surgery, focusing mainly on the surgeons. However, the surgeon is not alone in the OR, he or she is collaborating within a team. This also implies that surgery requires optimal teamwork behaviour, since a good surgical team performance not only depends on the technical, but also on the non-technical skills of each team member (Armitage-Chan, 2014; McCulloch et al., 2017). Non-technical skills are cognitive and social skills, which contribute to good task performance (Youngson & Flin, 2010). Such skills include situation awareness, communication, leadership and decision-making (Flin, Yule, Paterson-Brown, Rowley, & Maran, 2006; Yule et al., 2008) .

The importance of teamwork in medicine and surgery has been stressed by several authors (Manser, Howard, & Gaba, 2009; Pierre, Hofinger, & Buerschaper, 2011; Wahr et al., 2013). Important aspects of teamwork are the quality of the collaboration, shared mental models, coordination, communication and leadership (Healey, Undre, & Vincent, 2004; Manser, 2009; Undre, Sevdalis, & Vincent, 2009; Weaver et al., 2010). These are similar to the different non-technical skills, which shows the importance of non-technical skills for teamwork. For these to actually work in favor of teamwork, there has to be mutual respect, and mutual understanding of the shared goals between the team members (Manser et al., 2009)

Considering teamwork, teams in surgery face additional challenges. A surgery is executed by a team consisting of surgeon (-s), scrub nurse (-s), circulating nurse (-s), anaesthesiologist (-s) and sometimes others (e.g. medical students, technicians), making the team interdisciplinary. Interdisciplinary teams face additional challenges, because of different roles and perspectives in communication (Undre, Sevdalis, Healey, Darzi, & Vincent, 2006; Weller, Janssen, Merry, & Robinson, 2008). Those are, among other things, influenced by different patient care models and responsibilities, the assumptions of other team member's roles, and different training methods of the different disciplines (Lingard, Reznick, Espin, Regehr, & DeVito, 2002; Reader, Flin, Mearns, & Cuthbertson, 2007). Not only are there individuals from different disciplines, but also the team composition often changes frequently, sometimes within a surgery, but certainly between surgeries. Especially in big surgical wards with many employees, team composition is not stable, since healthcare has to be provided 24 hours each day. Those factors hinders the team from developing familiarity, because the individuals do not necessarily work often together and are also rarely trained together (D. P. Baker, Day, & Salas, 2006). Team familiarity describes a common experience as members of the same team and is an important element for teamwork performance (Gillespie et al., 2017; Kurmann et al., 2014). Team members working a longer time together develop routines and gain mutual experience, which allows them to collaborate better. One study found fewer miscommunications in teams who have been working together a longer time (Gillespie et al., 2012) and another study found a reduction in morbidity following major abdominal surgeries when the same main surgeon and junior surgeon were a stable team for six months (Kurmann et al., 2014).

Since surgical teams are interdisciplinary and often not very familiar with each other, it is even more important for them to have a functioning and clear communication with each other. Communication, as a non-technical skill, plays an important role regarding the performance of teams in general and in surgery. As different studies show, teamwork and communication are indeed critical components of safe healthcare systems (Weaver, Dy, & Rosen, 2014). Communication related to the task in general enhances team performance (DeChurch & Mesmer-Magnus, 2010; Mohammed & Dumville, 2001; Waller & Uitdewilligen, 2008). For surgical teams, Mazzocco et al. (2009) and others showed that more intraoperative information exchange was related to less patient complications and Tschan et al. (2015) found in an observational study, that the exchange of more patient (or task-) relevant information during the procedure was related to fewer surgical site infections.

One of the mechanisms linking task-relevant communication in the OR to outcomes may be that communication contributes to an important component of successful teamwork - team situation awareness (Greenberg et al., 2007; Hu, Arriaga, Peyre, et al., 2012; Steelman, Shaw, Shine, & Hardy-Fairbanks, 2018). Team situation awareness is defined as the common understanding of the situational information available to the team members and a common perspective of the course of the task or situation (Graafland, Schraagen, Boermeester, Bemelman, & Schijven, 2015; Parush et al., 2011).

Team members can cooperate better if situation awareness is high, because they can anticipate developments and prepare their own contributions accordingly. The exchange of important information helps the team to develop a common anticipation of the task, (Westli, Johnsen, Eid, Rasten, & Brattebo, 2010), what makes anticipating of task developments easier for team members, which leads to better team coordination (DeChurch & Mesmer-Magnus, 2010; Mitchell et al., 2010; Weaver et al., 2010). In an interview study, Gillespie, Gwinner, Fairweather, and Chaboyer (2013) found that the building of team situation awareness was facilitated by efficient communication. Along with generally sharing task information explicitly, surgeons talking to themselves and scrub nurses actively listening to the conversations at the table increased their respective situational awareness.

In view of the importance of good communication, there are attempts to prevent communication errors. Team training interventions can improve teamwork and communication in the OR, leading to better patient outcomes (e.g. decreased mortality, less adverse events) (Biccard et al., 2016; Gillespie, Chaboyer, & Murray, 2010; Weaver et al., 2014). Concerning their efficiency, it has been shown that changes in clinical practice often lead to a greater reduction effect of surgical morbidity than team training (e.g. general training courses) (Hicks, Rosen, Hobson, Ko, & Wick, 2014; McCulloch, Rathbone, & Catchpole, 2011; Neily et al., 2010; Wolf, Way, & Stewart, 2010). Therefore, structural changes may be more beneficial for the surgical teamwork than additional training (Kurmann et al., 2014).

One example of such a structural change is the introduction of preoperative surgical safety checklists. Such checklists before the surgery contain items as reminders for critical safety steps and are verbally confirmed to the whole team by the responsible team member for this safety step (World_Health_Organization, 2009). Preoperative checklists are a widespread tool to increase patient safety with comparatively little effort, by promoting communication and teamwork (Borchard, Schwappach, Barbir, & Bezzola, 2012). Additionally to the preoperative checklist, our research group has implemented a briefing intervention based on similar principles and further considerations; the StOP? protocol, which is carried out during surgeries. In the next chapter, I will first provide background on preoperative checklists and its effects on teamwork and communication and will based on this describe the StOP? protocol and its intended goals.

3.2 Surgical Checklists and Briefings in the Operating Room

A tool to foster communication in the team is the surgical safety checklist. The World Health Organization (WHO) published a checklist-based briefing in 2008 and suggested that surgical teams perform safety checks during the perioperative phase. Since then, numerous surgical departments

worldwide have incorporated the WHO Surgical Safety Checklist (Gillespie et al., 2014; Jammer et al., 2015).

The WHO Checklist has three sections: the sign in (before induction of anaesthesia), the time out (before skin incision) and the sign out (after wound closure, before the patient leaves the OR) (World_Health_Organization, 2009). I will only elaborate on the time out, since this is the most relevant in terms of the topics of the following chapters.

The timeout, also called team timeout (TTO), is performed by the entire surgical team and is done at the time the anesthetized patient is already prepared in the OR, just before the incision. The WHO checklist used for the TTO consists of questions regarding information about the patient identity, the planned procedure, antibiotic prophylaxis, possible critical events and display of essential imaging. Since cultural differences between hospitals exist, the WHO suggests, that additions and modifications to the checklist should be made to fit local practice (World_Health_Organization, 2009).

The main goal of the TTO is to increase patient safety, by serving as reminder tool. Safety check items are performed to avoid mix-ups like wrong-site or wrong-patient errors. The use of TTOs has indeed helped to reduce the rate of adverse events, patient morbidity and even mortality (Einav et al., 2010; Hicks et al., 2014; Thomassen, Storesund, Søfteland, & Brattebø, 2014).

Apart from the positive effect of the TTO on adverse events, it also showed to be beneficial for the collaboration and teamwork during surgeries (Paige et al., 2008). After the introduction of the TTO, surgery team members perceived collaboration and communication as improved (Cullati et al., 2014; Kearns et al., 2011; Nugent et al., 2013; Paige et al., 2008; Takala et al., 2011) and there was indeed a significant decline of communication failures after its introduction (Lingard et al., 2008). Concerning communication, the TTO is also important in terms of speaking up.

Speaking up means a person in a team raising concerns for the benefit of safety after recognising that the action of others within the team may be harmful (Okuyama et al., 2014). Therefore speaking up is voicing ideas, questions or concerns in a team (Edmondson, 2003; Eppich, 2015), and has been shown to contribute to preventing mistakes and to identifying and correcting errors (Edmondson, 2003). Nevertheless, voicing concerns also bears interpersonal risks, which make team members hesitant to speak up (Etchegaray, Ottosen, Dancsak, & Thomas, 2017; Landgren, Alawadi, Douma, Thomas, & Etchegaray, 2016; Okuyama et al., 2014). For team members to speak up, there has to be an environment which encourages speaking up. Salazar et al. (2014) let medical students assist in a simulated laparoscopic surgery where the senior surgeon either encouraged or discouraged speaking up. At one point, the senior surgeon gave an instruction for the student, which they learnt, would harm the patient if executed. Students in the encouraged group spoke up significantly more, than the ones in the discouraged group. With the regular use of the TTO, the team

members get used to speaking to each other about safety concerns, which normalizes speaking up and creates an environment appropriate to speak up. Therefore speaking up in the OR is encouraged by the use of the TTO (Molina et al., 2016; Weller et al., 2018).

Another benefit of the TTO is saving time. Through the improved communication, the team is better able to anticipate task developments, which improves coordination, leading to fewer delays (Anderson et al., 2017; Semel et al., 2010). All the benefits of the TTO taken together can even help to save money (Anderson et al., 2017; Semel et al., 2010).

However, evidence is mixed regarding some studies that did not replicate some of the positive effects of the safety checklist (Erestam, Haglind, Bock, Andersson, & Angenete, 2017; Urbach, Govindarajan, Saskin, Wilton, & Baxter, 2014). One possible reason for replication failures could be due to a low quality of the execution of the TTO. Despite it being a simple tool, the introduction and the correct use of the TTO are not self-evident. Poor implementation approaches can lead to omission of checklist items and inattention to the discussed items (Levy et al., 2012; Russ et al., 2015). A poor execution of the TTO is not harmless, as the completeness and the overall quality of the TTO is related to its outcomes (van Klei et al., 2012). Thus, participation and commitment by all team members is essential (Hicks et al., 2014; Vogts, Hannam, Merry, & Mitchell, 2011).

Taken together, the TTO, a short team-based briefing at the beginning of the surgery has shown to have positive effects for the patient and the surgical team. Although information exchange before the procedure starts is important, some of this information may become obsolete as the surgery goes on. Especially in long and not very standardised surgeries it is possible that events occur that were not foreseen at the time of the timeout (e.g. unexpected complications, failing instruments). In such situations, the team may be in need of an update during the surgery. Keeping the team members informed by giving information to the whole room has shown to be important in crisis situations (Kolbe et al., 2014; Waller & Uitdewilligen, 2008) and for sense-making in ambiguous situations (Tschan et al., 2009).

Therefore, communication of task-relevant information during surgery is important (Anderson et al., 2017), but this often does not occur as a matter of course and critical information is often transferred in a reactive way (Lingard et al., 2002). Several aspects may contribute to the fact that often, there is too little exchange of task-relevant communication within the surgical teams.

A first reason is that particularly for the responsible surgeon, sharing information with the team can be difficult. Surgeons have to perform taskwork (perform surgery) and teamwork (coordinate the team) (Marks, Mathieu, & Zaccaro, 2001) during the OR. Taskwork and teamwork are two different processes that both require attention, albeit at two different levels (McGrath & Tschan, 2004; Okhuysen & Eisenhardt, 2002). Performing surgery is often a difficult sensory-motoric task, which

requires full attention of the operating surgeon. Communicating updates to the team consumes attentional resources, which are possibly interfering with the concentration needed to perform the surgery properly. One can therefore not expect from surgeons that they provide information to the whole OR team while operating at the same time. Interrupting the procedure to inform the team could be perceived as disruption from the natural progression of the surgery (Weigl et al., 2018), which could not only distract but also interrupt the surgeons flow experience of doing surgery (Friedman et al., 2018). Therefore, informing the team could be seen as having to perform a disruptive and emotionally unpleasant activity. Even if the surgeons have time to provide more information for the team, they may not see this as a necessity. The surgeons themselves may not realise that other team members do not have the information they have about the current surgery. Which could lead the surgeons to underestimate the need for communication and overestimate situation awareness of the surgical team (Wauben et al., 2011).

There is also the problem of speaking up. As described earlier, speaking up is not easy, because of possible interpersonal risks (Etchegaray et al., 2017; Landgren et al., 2016; Okuyama et al., 2014). While the timeout promotes speaking up at the beginning of the procedure, speaking up may be even more difficult during the surgery. Over the course of the surgery, the surgeon may be highly concentrated and other team members are not sure if speaking up at this moment would disturb the surgeon's current work.

For these reasons, it might be useful to conduct an intervention that helps to support task-relevant information exchange during surgery. To do so, our research team developed an intraoperative briefing, the StOP? protocol. The StOP? protocol has the goal to assure the exchange of task- and cooperation-relevant information during surgeries. The StOP? protocol ("StOP?" in short) can be done multiple times during the surgery, depending on the needs of the team for the current procedure. A StOP? is conducted as followed: the responsible surgeon pauses the surgery and informs all team members in the OR about the current status of the surgery (St), the next steps and objectives (O), possible problems (P), and explicitly encourages team members to speak up and ask questions (?). To account for the high variety of surgery characteristics (e.g. length, standardisation) the StOP? is task-based and is done at specific moments during the surgery (e.g. critical phases, change in OR personnel) and not at a strict time. The amount of and the planned moments when the StOP?(s) will be done is announced by the responsible surgeon during the timeout before the incision. There is a more elaborated description of the StOP? in the StOP? introduction paper, therefore I refer here to the manuscript (chapter 3.3) to avoid too much repetition.

The time necessary for a StOP? is very short (30s-2min). Such short briefings can be done even when the general time is limited (Gururaja, Yang, Paige, & Chauvin, 2008). Studies about the timeout and debriefings have shown that even a very short self-led briefing can influence the team

performance positively (Garden, Le Fevre, Waddington, & Weller, 2015; Levett-Jones & Lapkin, 2012; Lingard et al., 2008; Paige et al., 2008), such considerations most likely apply for the StOP?.

The StOP? therefore has the potential to be beneficial for teamwork and subsequently for patient outcomes. However, it may be difficult for a surgical team to regularly implement and follow the StOP? protocol. Like with the TTO, participation and commitment by all team members is an essential condition for a possible impact (Hicks et al., 2014; Vogts et al., 2011). Research on TTO has shown that positive effects of briefing interventions depend on the compliance of the surgical team to actually follow the TTO protocol, and that the efficiency of interventions increases with increasing compliance (Anwer, Manzoor, Muneer, & Qureshi, 2016). Suboptimal compliance may lead to an underestimation of the potential effects (de Vries et al., 2010). With insufficient compliance, it is even possible that positive effects of interventions do not emerge at all (Bergs et al., 2014; van Klei et al., 2012).

Studies about the introduction of the timeout have found several influences on compliance. The intervention should have the involvement and support of key people (Kearns et al., 2011; O'Connor, Reddin, O'Sullivan, O'Duffy, & Keogh, 2013; Papaconstantinou, Jo, Reznik, Smythe, & Wehbe-Janek, 2013; Russ et al., 2015; Styer, Ashley, Schmidt, Zive, & Eappen, 2011; Thomassen, Brattebø, Heltne, Søfteland, & Espeland, 2010). Not only key people, but all staff should be involved actively from the beginning of the introduction of the intervention (Kearns et al., 2011; O'Connor et al., 2013; Russ et al., 2015), because this helps them understand the purpose of the intervention which increases acceptance (Lyons & Popejoy, 2017; Mascherek & Schwappach, 2016). The intervention has to be adapted to the respective environment and the particularities of the groups (Gillespie, Marshall, Gardiner, Lavin, & Withers, 2016). After all staff is on board, introduction and training play a crucial role in preparing the team for the change, in addition, continuous feedback should be given (O'Connor et al., 2013; Papaconstantinou et al., 2013; Russ et al., 2015).

Even when taking these aspects into account while implementing an intervention, there are also context-based factors which could influence compliance. When implementing safety-related measures, the specific hospital culture has been found to play a role. The healthcare organisation's culture is a key factor not only for the development of a safety climate, but also for implementations of quality improvement projects (Speroff et al., 2010). Therefore, compliance may be different across hospitals (Aveling et al., 2018), although results on this topics are mixed (Cullati et al., 2014; Delgado Hurtado et al., 2012; van Schoten et al., 2014). Another influence on compliance may be aspects of the surgical procedure itself and its circumstances. Van Klei et al. (2012) found the lowest compliance in sicker and more urgent patients and Cullati et al. (2013) found higher compliance with longer major interventions compared with smaller procedures.

Considering all the previous research reported in this chapter, the described StOP? protocol should be beneficial to the operation room team, if the introduction and execution is done correctly. The next four chapters contain manuscripts that discuss different aspects of the StOP? intervention, corresponding with topics described in this chapter.

The StOP? introduction paper (chapter 3.3) describes the conceptualizing and implementing of the StOP? protocol. The idea and concept of the StOP? was developed based on theoretical considerations as well as finalized based on interviews with surgeons and other surgical team members. In the interviews, surgeons stated at which points during surgery they consider a StOP? feasible and useful, allowing to adapt the StOP? to the specific tasks and hospital systems.

As described above, good compliance is essential for an intervention to have possible positive effects. In the StOP? compliance paper (chapter 3.4), compliance with the StOP? was measured, using different kinds of compliance measures. Additionally, possible context and task-related factors influencing the compliance were evaluated.

The StOP? and the team timeout have similar goals and mechanisms. Although the StOP? is done at a different point in time, the addition of another briefing could influence the quality of the first. On the one hand, there is the fear of possible checklist fatigue (Hales & Pronovost, 2006), when the team feels annoyed by doing additional briefings because of felt redundancy (Fourcade, Blache, Grenier, Bourgain, & Minvielle, 2012). This can lead to a possible disengagement and quality drop for a briefing. On the other hand, drawing attention to the group level can influence cooperative behaviour in groups (Okhuysen & Eisenhardt, 2002). Therefore, an additional group briefing could positively affect the team timeout. The timeout paper (chapter 3.5) studied possible effects of the StOP? on the timeout in terms of completeness and quality, based on an observational study.

The StOP? protocol has the goal to foster the exchange of task- and cooperation-relevant information during surgeries, supporting the situation awareness and the ability to speak up of the surgical team. To check if the StOP? protocol fulfils this goal, the situation awareness and self-assessed ease of speaking up of the surgical team members before and after the introduction of the StOP? protocol was measured and compared in the StOP? team paper, based on observed surgeries (chapter 3.6).

3.3 Manuscript on StOP? Introduction

This chapter contains the manuscript on the StOP? protocol introduction with the title: “Preparation and implementation of intraoperative briefings to enhance teamwork during surgeries: The StOP? Protocol”. Not all interview data is analysed yet, therefore missing in the current manuscript.

Preparation and implementation of intraoperative briefings to enhance teamwork during surgeries: The StOP? Protocol

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This research was supported by the Swiss National Science Foundation Grant Nr 156882 and by the Robert Bosch Stiftung. The grant agencies had no influence on the research.

Abstract

Background: Good communication and information exchange during surgeries influence surgical performance and are related to patient complications. To support intraoperative communication, an intraoperative briefing intervention was developed to ensure good communication during surgeries. For the StOP? protocol, the responsible surgeon pauses the surgery and informs the surgical team about the current status (St) and objectives (O) of the surgery, problems that may occur (P), and provides a speak up opportunity in explicitly asking the team members for contributions (?).

Goals: To evaluate feasible interruption points in different surgeries to perform a StOP? briefing and to adapt the StOP? briefing to local hospital cultures.

Methods: Semi-standardized interviews with main surgeons were conducted in four hospitals. The surgeons were asked to describe and identify the opportunities for a StOP? briefing during a surgery they frequently performed.

Results: Interviews of 23 surgeons were included. Surgeries discussed included appendectomy, cholecystectomy, hernia repair, weight-loss bariatric procedures, hemicolectomies and sigmoidectomies. There was a reasonable overlap with regard to the ideal points in time to engage in a StOP? briefing. Preferred points in time were after initial exposure, before important steps (clipping vessels, unpacking mesh, before anastomosis) and, for some surgeons, after having completed and controlled an anastomosis.

Conclusion: For the StOP? protocol to be useful and feasible, adaptions to the task and the system have to be identified and realized. Adaptions may be necessary for the specific hospital, the specific surgery, and the individual preferences of the involved surgeons.

Keywords: Surgery, team training in surgery, formal communication in surgery, teamwork

Introduction

Team training in surgery

Effective teamwork is undeniably an important factor for high surgical performance (Beldi, Bisch-Knaden, Banz, Muhlemann, & Candinas, 2009; K. R. Catchpole et al., 2007; Healey, Undre, & Vincent, 2006; Weaver et al., 2010). There is, however, evidence that teamwork in the operating room (OR) frequently is far from being perfect (Cochrane, Muniak, & Kennedy, 2018; Gawande, Zinner, Studdert, & Brennan, 2003; Greenberg et al., 2007) and may need improvement (Leape, 2014). However, interventions to foster teamwork for surgical teams are still scarce (Brigid M. Gillespie, Chaboyer, & Murray, 2010; Ounounou et al., 2019; Weaver et al., 2010), and results of teamwork training on performance are inconclusive (Sun, Marshall, Sykes, Maruthappu, & Shalhoub, 2018).

There are three main approaches to foster teamwork during surgery. The first and best known is the implementation of the World Health Organization (WHO) surgical checklist (Haynes et al., 2009) or other prebriefings (Brigid M. Gillespie et al., 2010). The WHO checklist's main goal is to limit "never-events" such as wrong site surgery, and to minimize omissions by using a standardized checklist of parameters that are specific for the current patient and procedure (surgical site, allergies, antibiotics, etc.). However, implementing the WHO surgical checklist has been shown to be beneficial for teamwork as well (Willassen, Jacobsen, & Tveiten, 2018).

A second set of interventions to support better teamwork in surgery is the training of generic team skills and generic tools to foster teamwork. Such interventions are, for example, team trainings based on Crew Resource Management (CRM), a team training initially developed for aviation teams (Aggarwal, Undre, Moorthy, Vincent, & Darzi, 2004; Morgan et al., 2014), or trainings based on the TeamSTEPPS (Team Strategies and Tools to Enhance Performance and Patient Safety) program (Clancy, 2007; Forse, Bramble, & McQuillan, 2011; King et al., 2008). In such trainings, individuals or teams are taught general teamwork or

nontechnical skills (Weaver et al., 2010), which are applicable for many different situations. Such trainings may include communication tools for difficult situations. Examples are instructions on how to speak up if one has concerns (Weaver et al., 2010), to interrupt an overwhelming situation with a short break in order to reflect (Rall, Glavin, & Flin, 2008); or a communication sequence that helps to express concerns in case of threats to patient safety, for example the two-challenge rule (Pian-Smith et al., 2009). Such skills are applicable to many different situations. However, being generic, they need to be applied to the specific team and the specific work situation, and team members need to identify the cues that indicate when to use them in a specific situation.

The third approach (McCulloch et al., 2017) adapts the training to a specific work setting (for example the OR), and in addition takes into account specificities of the system (e.g., the specific hospital) as well as specific aspects of the task (e.g., a specific surgery). An example for an adaptation to the system would be emphasizing a different content in training for a teaching hospital than for a hospital with less teaching, and an example for adaptation to the task would be emphasizing different aspects for open versus laparoscopic versions of the same surgery (K. Catchpole et al., 2018). By virtue of the adaptation to the system and the task at hand, interventions in the third category are the most specific.

In this paper, we present an intervention that belongs to this third category: We developed a system- and task-adapted intraoperative intervention (the StOP? protocol) aimed at fostering the exchange of case-relevant information in surgical teams.

Key aspects of intraoperative teamwork

Good cooperation and good teamwork in the OR depend on several factors. One important aspect is that a team needs to develop a shared representation of the task, of roles and responsibilities, and of the team process; this shared representation is often called a shared mental model (Klimoski & Mohammed, 1994; Mohammed, Hamilton, Sánchez-Manzanares, & Rico, 2017). Previous research found that more accurate mental models and a

higher degree of sharedness of the mental models are related to better team coordination and to higher team performance (Lim & Klein, 2006), this also holds for surgical teams (A. C. Edmondson, Winslow, Bohmer, & Pisano, 2003) . A shared mental model contains general features of task execution (e.g., knowing the steps and the tools needed for a specific anastomosis). This knowledge has to be complemented by situation awareness, which refers to an understanding of what is happening in a given moment (Endsley, 2015; Mohammed et al., 2017). For example, scrub nurses need to be aware that the surgeon is performing a given step and realize how far this step is from completion, they then can anticipate what step is likely to follow and prepare the appropriate tools (Parush et al., 2011).

Shared mental models and situation awareness have to be established in specific teams and to be adapted to the task at hand. During the team process, task-related communication and common reflection within a team (Goldenhar, Brady, Sutcliffe, & Muething, 2013; Schmutz & Eppich, 2017) are the main contributors to the development of shared mental models and situation awareness in surgical teams (Amy C Edmondson, Dillon, & Roloff, 2007; B. M. Gillespie, Gwinner, Fairweather, & Chaboyer, 2013; Hazlehurst, McMullen, & Gorman, 2007; Vashdi, Bamberger, & Erez, 2013).

Indeed, for surgical teams, a relationship between task-related communication and performance has been established: Pisano, Bohmer, and Edmondson (2001) showed that rates of learning in different hospitals that adopted a new surgical procedure were related to the extent of communication; a study showed that more information exchange during surgeries was related to less surgical complications (Mazzocco et al., 2009), and another study found that more case-relevant communication during surgeries was related to fewer surgical site infections (Tschan et al., 2015), this confirms meta-analytical results of the relationship between communication and team performance (Marlow, Lacerenza, Paoletti, Burke, & Salas, 2018). In addition, several studies found that communication problems and failures were related to poorer surgical performance (B. M. Gillespie, Chaboyer, & Fairweather, 2012;

Halverson et al., 2011; Lingard et al., 2004; Nagpal et al., 2010; Nurok, Sundt, & Frankel, 2011). In conclusion, improving communication in the OR is thus seen as one of the most important challenges in surgical patient safety (Stahel, Mauffrey, & Butler, 2014).

An intervention to foster the exchange of task-relevant information

To ensure good cooperation and good outcomes, fostering the exchange of task-related communication during surgeries is important (Song, Vemana, Mobley, & Bhayani, 2013). The question is whether that requires a special intervention; possibly, it suffices if members of surgical teams, notably the surgeons, are aware of this need and thus provide information and encourage information exchange. The nature of informal, in-process communication suggests, however, that a strategy of "simply augmenting information exchange" is not likely to succeed: A simulator study by Cumin, Skilton, and Weller (2017) illustrates this point. The study showed that in surgical teams, only 40% of patient-relevant information was shared. Furthermore, if this information was shared informally during the surgical process, only 1.4 team members (in a team of six) were attentive to the information, resulting in additional information loss. By contrast, if information was shared during formal communication opportunities, significantly more team members were attentive, and information shared during formal opportunities was five times more likely to be recalled by the team members (Cumin, Skilton, & Weller, 2017). This study shows that information has a particularly high probability to get lost if shared only informally during an ongoing process (Bogenstatter et al., 2009) and that formal information sharing is important. (Cumin et al., 2017).

The reasons for the superiority of formal communication opportunities as compared to informal communication during the surgical process are twofold. First, the attention of the team members has to shift between planning/coordinative activities and task execution (Marks, Mathieu, & Zaccaro, 2001; McGrath & Tschan, 2004). Those two processes require attention to different aspects – coordination requires attention to fellow team members and to the planning aspects of the task; task execution requires attention to the regulation of the task

itself. If executing the task requires full concentration, it is likely that the surrounding situation is not, or not sufficiently attended to, because people are focusing on their immediate task (Tschan, Vetterli, Semmer, Hunziker, & Marsch, 2011). If attention does turn to the surrounding team activities, however, task execution may be interrupted and suffer (e.g., a delicate suture not carried out as precisely as normally). In surgery, it is the main surgeon who holds most patient- and procedure relevant information and has a leadership role, and therefore is the main provider of information and coordinator of the team (Parker, Yule, Flin, & McKinley, 2011). At the same time, it is the main surgeon who carries out the surgery proper; thus, he or she is heavily involved in task work, which requires close attention to many details, such as sensory-motor aspects (Leff et al., 2017; Zander et al., 2017). Updating the team may thus draw attention away and interrupt the surgeon's main task, operating. Second, only team members working directly at the operating table (surgeons and scrub nurse) work in very tight cooperation. Anesthetists have their own tasks and coordinate closely only in specific moments of the surgery; the same holds for the circulators. These team members may be absorbed with their own tasks during an informal exchange of information (Vogts, Hannam, Merry, & Mitchell, 2011). In addition, ORs are often very noisy, noise levels often exceed recommended levels, and this has been found to impair communication (Healey, Primus, & Koutantji, 2006; Keller et al., 2016). Thus, team-members not directly at the table are likely to miss information.

Given that a) information needs to be updated during surgeries, b) that much of the relevant information is held by the main surgeon, and c) that informal information exchange may disrupt ongoing task execution by the surgeon and/or other team members, it follows that establishing formal opportunities for information exchange during surgical procedures may be a good way to insure task-relevant information exchange.

The StOP? intervention

Based on the theoretical background described above, a multidisciplinary team of surgeons, work psychologists and scrub nurses, with consultation of anesthesiologists, developed an intervention called the StOP? protocol. It has similarities to existing interventions in the medical field (e.g. Rall et al., 2008; Roberts et al., 2014). In contrast to most other interventions that concentrate on prebriefings or debriefings, however, the StOP? intervention aims at providing informational updates not before or after, but during the surgical procedure.

The StOP? is a specifically delineated formal and structured opportunity for sharing information during the surgical procedure. Although it may be suggested by any member of the team, it is the specific responsibility of the main surgeon to initiate it. When performing a StOP?, the main surgeon starts with a clearly audible announcement to the whole OR that a StOP? will be done. The surgery is interrupted at this time, and all members on the table are expected to stop working. Thus, the anesthetists, circulators and other non-sterile team-members are required to interrupt their work (or indicate that they cannot interrupt) and to approach the table; this assures attention of all team members in the OR. When carrying out the StOP? proper, the main surgeon informs the team according to the acronym "StOP?", where St stands for Status: the surgeon provides the state of the surgery and summarizes the work already completed, including unforeseen difficulties and adjustments to the initial plan. O stands for Objectives, where the surgeon outlines the next steps he or she intends to carry out. This is followed by information about potential Problems (P) that might be expected to occur. After providing this information, the surgeon explicitly asks for questions or contributions from the team (?). This last step was added to enhance the probability of team-members to speak up (A. Edmondson, 2003).

The following example is from a StOP? procedure in a liver resection surgery: Main surgeon: "Can we do a StOP? protocol, please?" (St) "We're in the abdomen, now; we've

mobilized the liver. No unexpected findings, (O) it looks like we can proceed with the final liver resection. (P) “It is bleeding a little bit more than usually, so you may be prepared for that”. Anesthetist: “yes”. (?) Main surgeon: “Any questions from the team?” Anesthetist: “So, this will be a one-step procedure?” Main surgeon: “It is still a little early to say. We haven’t really mobilized yet at the hepatic veins, so we need to do a bit more of mobilization, and intraoperative ultrasound. We will see”. Anesthetist: “Ok”. Surgeon “Thank you”. This StOP? lasted 43 seconds.

Adaptation of the StOP? intervention to system- and task-related aspects

As said above, it is important that a structured information exchange does not interrupt the surgical procedure at times the surgeon has to concentrate on the task. Therefore, the StOP? was conceptualized to be carried out at natural task-breaks during the surgery.

Predefined StOP?’s

Two occasions for StOP?’s were predefined by the development team. (1) If the responsible surgeon changes during the surgery (e.g., if fellow surgeons started the surgery and the senior surgeon joined during the procedure), a “Change-related StOP?” was foreseen. (2) Because it has been found that the last, closing phase of a surgery was vulnerable to a diminution of attention by the surgical team (Tschan et al., 2015), a StOP? at the time of sponge-counting to prepare for closing, a “Closure-StOP?” was also predefined. However, these predefined StOP?’s had to be adapted to the local hospitals.

StOP?’s adapted to the surgical procedure

The further StOP?’s had to be adapted to the specific procedures according to one or several of the following criteria: The surgeon can safely interrupt the surgery, optimally at a moment of a “natural break” during the procedure; there is information that can be communicated; if enhanced cooperation demands within the team are foreseeable; but also in case of changes of strategy or unusual occurrences. These surgery-specific adaptations were

discussed during instructive interviews with senior and fellow surgeons. The results are presented below.

Method

Procedure

After informing all surgeons about the intended intervention in meetings and by leaflets, we conducted semi-standardized interviews with main surgeons of four participating hospitals. All surgeons were either members of senior staff or fellow surgeons who were responsible for surgeries that corresponded with their specialty degree.

The interviews were conducted by one or two of five work psychologists familiar with the OR, but not necessarily with details of specific surgical procedures. First, the interviewer offered to provide background information about the planned protocol. In the interview proper, the surgeons were asked to explain the main phases of a surgical procedure they frequently performed. After this, they were asked to identify opportunities for performing a StOP? protocol during the procedures described. Interview probes for this phase were natural breaks during the surgery, points of no return, decision points, and tight cooperation within the team. Additional probes related to the effect or function of the StOP? protocol when performed (e.g., having the whole team on the same boat; informing the team about important changes; teaching). We also asked each surgeon whether he or she performed the whole surgery or whether in certain phases during the procedure, other surgeons were primarily responsible. Finally, we asked about the current practice regarding timeout and signout procedures according to the WHO checklist in their department.

Interview coding

All interviews were recorded, transcribed word-by-word and analyzed using atlas.ti, a software for qualitative data analysis (Dowling, 2008). The development of analytic categories was primarily deductive, based on the theoretical conception, with some inductively derived codes, particularly for the perceived functions of the StOP? protocol. This

follows the recommendation for coding development in qualitative research (Miles, Huberman, & Saldana, 2014). All quotes were translated either from German or from French by the authors.

The codes for surgical procedure described included: **Appendectomy** (removal of the appendix); all surgeons talking about appendectomy referred to a laparoscopic emergency procedure. **Cholecystectomy** (removal of the gallbladder) included elective as well as emergency procedures; all surgeons talking about cholecystectomy referred to the laparoscopic procedure. **Hernia repair** included all types of hernias. **Bariatric procedures** included elective weight-loss procedures. Surgeons referred either to Roux-en-Y gastric bypass surgery or sleeve gastrectomy. **Colectomies** (removal of part of the large bowel) included hemicolectomies and sigmoidectomy; laparoscopic or open procedures with or without temporary or terminal colostomy.

StOP? opportunity was coded if the surgeons described where in a procedure they considered that a StOP? would be useful. Relevant codes were **after initial exposure, at natural breakpoints of the surgery, before critical phases, at changes of the initial surgical strategy.** For the current analysis, we summarized those codes into the general code **StOP? opportunities**.

Analytical strategy

The search-strategy to identify relevant passages in the interview was to combine the code for a specific surgical procedure with the code for StOP? opportunities, using the co-occur analytic command of atlas.ti. It extracts all text passages where the two codes co-occurred in any way (within, encloses, overlaps or is overlapped by). For each of the surgeries, the relevant surgical phases were described based on surgical literature. These phase-descriptions were then matched with the descriptions given by the surgeons, and StOP? opportunities were assigned to those phases.

Results

Overall, 55 interviews with senior or fellow surgeons were conducted. For the current analysis, we included the answers of 23 surgeons that talked about one or several of the following procedures: appendectomy, cholecystectomy (removal of the gallbladder), hernia repair, bariatric (weight-loss) surgery, and surgery related to the large intestines (colectomies), see Table 1.

Table 1: Overview of surgical procedures described

Procedure	# of surgeons explaining this procedure	hospital1	hospital2	hospital3	hospital4
Appendectomy	2	0	0	1	1
Cholecystectomy	5	1	0	2	2
Hernia repair	8	2	1	2	3
Bariatric procedures	6	3	1	1	1
Colectomies	9	4	1	1	3

Note: Some of the 23 surgeons interviewed explained more than one procedure

Opportunities for StOP?'s in different surgical procedures

StOP?'s during appendectomy. Two surgeons described appendectomies. Both expressed that an appendectomy is normally a fast and easy procedure and is often performed by a junior surgeon under supervision. Both surgeons suggested a StOP? after the initial exposure, to inform the team whether the appendix was located where expected and whether there were many adhesions to remove. *"Identifying the appendix is normally not difficult […] one … can say 'OK, this is a simple case, the appendix is where we expect it to be and we can reach it easily' or 'it is difficult, the appendix lies retrocaecal […] or there are many adhesions" [..] "if the resident is operating, […] this may not the ideal moment to learn this and we may change surgeons at this moment" (D8:31).* The other surgeon said that for an appendectomy, the StOP? may not be useful *"except one realizes that the surgery takes much longer than planned, this could be a reason everyone needs to be all ears […] it is important*

for the anesthetist to know that (the surgery) can last another two plus hours. Sometimes, we miss this moment" (D53:11).

StOP?'s during Cholecystectomy. Six surgeons described laparoscopic cholecystectomy. All of them spontaneously said that they would choose the moment before dividing the hepatic arteries by clips and clipping the cystic duct for the StOP?. As a reason for choosing this phase, one (junior) surgeon said *"one has to be 100 per cent sure to be right [..] one has to take time, until it is clear. This is sometimes difficult" (D3:12);* and a (fellow) surgeon stated *"if that (situation) looks difficult [...] one could say for example: it is difficult to see and there is inflammation, we do not know how long the cystic duct is and how far we are from the main bile duct. One may have to do a cholangiography [imaging of the bile duct by x-rays], and would formally decide this at this moment. This is relatively often the case" (D8:9).* A surgeon mentioned that it would be useful for the anesthetists to have the StOP? at this moment *"We only have to remove the gallbladder from the liver bed and excise it after this moment. [..] Depending on the level of difficulty, the surgery will be over in twenty to thirty minutes [..] and the anesthetists can call for the next patient". (D27:11),* Another surgeon stated that *"Before putting the clip, we anyway need another instrument; we need to communicate anyway at this point" (D29:4).* As for appendectomy, cholecystectomy is often a teaching procedure. A surgeon said that she always identifies the structures together with the resident and at this point *"[..] we go back and we control again where everything is [..] that's a good moment to do it [the StOP?]" (D5:12).*

StOP?'s during Hernia repair. Eight surgeons described a hernia repair procedure, all of them referred to this surgery as a minor and normally short and easy procedure to perform. Two surgeons stated that among all general surgeries, they expected the least benefit of the StOP? for hernia repairs, and one suggested to only perform a StOP? if unforeseen aspects surface. One surgeon suggested to combine the WHO checklist procedure with the first StOP?, and four surgeons suggested a short StOP? after initial exposure. *"After we*

introduced the laparoscope. Where is the hernia? Do we need a mesh? We do this habitually". (D9:17), another surgeon described this as "a possible incarceration of the hernia (...) or we find an intestinal necrosis (...) this changes (the procedure) (37:3).

Seven surgeons identified the phase before implanting the mesh as one ideal moment to perform the StOP? in hernia procedures, because there is a natural break during the surgery, and the time left is predictable. *"This is a highly standardized routine surgery. There is one moment after the preparation is done, we have to decide which material we take, normally a mesh. At this time, I have to communicate and order it. This is also the moment I can predict almost to the minute how long (the surgery) will last (...). At this time, we do not expect any big surprises anymore". (D28:7) "[...] before we implant the mesh, we cut the mesh, and before we implant and fix it we do a StOP?, there are about 30 minutes left" (D27:10).*

StOP?'s during bariatric procedures. Four surgeon described Roux-en-Y gastric bypass and two surgeons described sleeve gastrectomy, all of them mentioned that these surgical procedures are highly standardized.

For the *bypass* surgery, two surgeons planned a StOP? at the time of exposure, and all surgeons planned a StOP? around the anastomosis - three surgeons before, and one after the anastomosis. *"There (before anastomosis) it is important that everybody is informed that this phase can be tricky for me. The anesthetists need to be ready (..) and the stapler needs to be ready so they can hand it to me directly" (D10:4). The surgeon preferring the StOP? after the anastomosis said "After the connection between stomach and intestines is done, we have reached a point where it becomes predictable, it should work (..) the difficult part is done" (D28:9).* One surgeon planned an additional StOP? at the creation of the proximal gastric pouch "*When I make this little pocket with the anesthetists. There are nasogastric tubes in the esophagus and in the stomach. The first criterion is not to staple them when you create the pocket (..) So, we stop the operation before stapling, we do it automatically" (D39:1).*

Both surgeons who described sleeve gastrectomy identified the moment before dissection of the stomach as an ideal moment to do a StOP?. *"(..) there are (..) pitfalls (…) if we remove the upper part of the stomach, this is very close to the esophagus, and that can be tricky (..) the anesthetists need to sedate the patient well (…) because also the spleen is close and complications can happen (..) I need the attention [of everybody]." (D10:8).*

StOP?'s during colectomies (resection of part of the colon). Five surgeons explained hemicolectomies and eight surgeons explained sigmoidectomy (resection of the sigmoid colon). All surgeons suggested several StOP?'s during these surgeries.

For hemicolectomies, all five surgeons planned a first StOP? after initial exposure and a second StOP? before anastomosis. *"The first (StOP?) is after exposure when we see if there are metastases, or not. Can we perform the surgery as planned or do we need a change of strategy? Can we continue with minimal-invasive surgery or not? Can we operate at all? And then certainly another StOP? at the moment when we reflect before dissecting the colon. Where we decide on where to resect and say: OK, this will be irreversible" (D21:3). "The second (StOP?) implicates the anesthetists more, because they know that the second part, the anastomosis, will start soon (...) it is then possible to estimate the remaining time. For the scrub nurses (…) they need other instruments. This StOP? again, is very natural." (D21:4).*

For the sigmoidectomy, six of the eight surgeons planned a StOP? after the initial exposure; two surgeons found a StOP? useful before vessels were clipped; both were fellows who were second surgeons for this procedure. *"This is like an outlook we will clip, then we proceed there and there and there. And (..) if I know that we have to take a decision I cannot take by myself, I say: 'There we take a break. And discuss the strategy"* (D20:18); the other surgeon who wanted a StOP? before clipping referred to surgery with two parallel surgical teams that was recently introduced in the hospital: *"The more experienced team is doing the transanal access (..) and we start from above (..) that one of the experienced [surgeons] tells me, it is looking good. This gives me security and I can continue. Even one word is sufficient"*

(D27:4). Six of the eight surgeons planned a second StOP? when the surgical team temporally changes to a minilaparotomy to perform the anastomosis. *"We use staplers, two parts that are put together. One is sewed in. And then we come through the rectum and put all together with a semi-automatic seam (...). No doubt, this is the most important StOP? (...)" (D20:10) "But then, we need them [the scrub nurses], when we do the small incision for the anastomosis [..] we need another table and a lot is happening in a short amount of time (D24:7).* Two surgeons planned a conditional StOP? at the time of intraoperative decisions. *"It is not that rare* [for this surgery], *we have to decide whether to do [..] a definitive colostomy - or not. Others do this differently; they always decide in advance. But I believe that we can push the limits, securely push the limits, if we take this decision also during the surgery (...). And there, things are very clear: that's something important for everybody (...) this is a StOP?"* (D20:16). Three surgeons planned another StOP? after the control of the anastomosis was done, all three had also planned a StOP? before the anastomosis. Two hospitals had recently started to perform sigmoidectomies with two teams. For this surgery, again, surgeons planned StOP's before the anastomosis. *"(..) there are two teams (..) a difficult and potentially chaotic situation, because we have two towers (...) there is lot of equipment in the room and two scrub nurses (..) where to do (the StOP?). Probably again before the anastomosis (..) this is the best moment." (D24:8).*

Table 2 summarizes the results. The colors illustrate the agreement between the surgeons with regard to the StOP? procedure, the darker the color, the more agreement between the surgeons.

Table 2: Overview of StOP? opportunities chosen for different surgical procedures

	n	StOP not useful	after initial exposure	before clipping	before dissecting	before unpacking the mesh	before ana-stomosis	after ana-stomosis	only if un-expected difficulties	other
Appendec tomy	2	1/2	1/2		NA	NA	NA	NA	1/2	
Cholecyst -ectomy	6			6/6	NA	NA	NA	NA		before excising endobag (1)
Hernia repair	8	2/8	4/8	NA	NA	7/8	NA	NA	1/8	with WHO checklist (1)
Bariatric surgery bypass	4		2/4	NA	NA	NA	3/4	1/4	1/4	At creation of gastric pouch (1)
Bariatric surgery sleeve	2			NA	2/2	NA	NA	NA		
Hemi-colectomy	5		5/5			NA	5/5			
Sigmoid-ectomy	8		6/8	2/8		NA	6/8	3/8		

Note: N=23 surgeons, some of whom talked about more than one procedure. The first number represents how many of the surgeons talking about the procedure planned a StOP? at this moment, the second number is the total of surgeons who talked about the procedure. Darker colors represent more agreement, lighter colors less agreement among surgeons. NA: This phase is not relevant for the specific procedure

Usefulness of predefined StOP?

In the interviews we assessed for each surgeon whether the predefined StOP?'s (Change-StOP? and Closure-StOP?) was feasible for their procedures. All surgeons in hospital 2 and 4 confirmed that change of responsible surgeon during the procedure was very unlikely in their hospital, whereas all surgeons in hospital 1 and 3 confirmed that such changes were common, because fellow surgeons often started the procedure with a senior surgeon joining for the most difficult middle part of the surgery. Surgeons from hospital 2 confirmed the existence of a signout procedure at the time of last sponge count and stated that the predefined Closure-StOP? would be redundant with this signout.

Discussion

The interviews revealed several issues that needed to be considered when developing and introducing the StOP? protocol. These refer to common characteristics of StOP?-prone situations as well as to adaptations to the task and the system.

In terms of communalities, it first is important to note that most surgeons agreed that there are occasions when a StOP? protocol can / should be implemented without representing an unwelcome interruption. Only three times surgeons concluded that StOP? would not be useful for their type of surgery (see Table 2), for short and relatively simple procedures. Furthermore, many surgeons mentioned a slot for the StOP? protocol at one or two occasions that have similar characteristics. The first occasion is a situation that is critical in that it requires utmost concentration in order to avoid mistakes. Before clipping in cholecystectomy is an example: It must be precisely at the right place in order to avoid damage; another example refers to initial exposure in hemicolectomy and sigmoidectomy, where it is especially important to consider the specific situation of the patient. Sometimes, these situations involve a (potential) change in strategy, as reflected in the quote of a surgeon describing a well-established procedure: "…As if we were doing the surgical report, using standardized text blocks. Each time we deviate from this, we need a StOP?". These situations profit from interrupting ongoing actions and deliberately focusing on the next step; they might be characterized as reflection necessities. Note that agreement about these situations is rather high but specific for the type of surgery (Table 2).

The second occasion refers to situations where more team members have to be involved anyway; an example is unpacking the mesh; such situations might be characterized as a coordination opportunity. Again, high agreement and surgery-specificity can be noted, as shown in Table 2.

In terms of differences, adaptations may be necessary at the level of the hospital, the specific surgery, and individual preferences.

Regarding hospitals, regular changes of surgeon responsibility occurred only in the two University hospitals. In these hospitals, the main surgeons often performs only the main part of the surgery, leaving mobilization and suturing to a junior surgeon; they may not even be present during the first and third phase. In such situations, a StOP? seems natural when a

change in the acting surgeon occurs. In the two other hospitals, such a change often does not occur, and such “Change-StOP?’s” make no sense. One hospital had established the intraoperative sign-out procedure suggested by the WHO at the time of sponge count. For this hospital, the “Closure-StOP?” was not introduced because the hospital already had a procedure satisfying this function. These adaptations are in line with the need to take into account already existing procedures in different hospitals and to adapt the intervention accordingly (McCulloch et al., 2017).

Regarding surgeries, Table 2 clearly demonstrates that the critical points that make a StOP? protocol useful or feasible strongly depend on the specific surgery. Discussing these specific points with the surgeons was very important for implementing the StOP? protocol, as each surgeon could apply the general criteria specifically to his or her procedure.

Regarding individual preferences, Table 2 demonstrates that some surgeons preferred a StOP? before, some after a critical situation. Usually, there are good arguments for both, and it makes no sense to prescribe one or the other to the surgeons. Leaving the choice to them respects their specific experience and also is likely to contribute to the acceptance of the StOP? protocol and to higher compliance.

Often, potential StOP? situations were described as situations where communication “occurred anyway”. To the extent this is true, the StOP? protocol is but a formalization of naturally occurring behaviors. However, the degree to which such behavior does, indeed, “occur anyway” varies greatly. There are surgeons who may be quite comfortable communicating; these tend to seize such opportunities. Others may be less comfortable communicating, and for them an “official trigger” is likely to increase the probability for communication to actually occur.

Conclusions

The need for good communication in surgery teams is hardly disputed. However, such communication occurs “naturally” to very different degrees and in very different quality. The

StOP? protocol is a means of establishing a procedure that ensures communication at critical points without imposing an unwelcome interruption. Although general team training may yield positive results (Neily et al., 2010), it is widely recognized that interventions should be adapted to the specific circumstances, such as the specific hospital, the specific procedure, and the individual preferences of the surgeons involved. This adaptability was ensured in our project by conducting interviews with surgeons who described their procedures and the critical phases involved, so they could determine when to use the StOP? protocol. We feel that this individualized development of the specific application of the protocol ensured maximal adaptation and flexibility while preserving the basic thrust of the intervention. At the same time, this (rather time-consuming) way of preparing the project fostered the commitment of the surgeons involved.

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3.4 Manuscript on StOP? Compliance

This chapter contains the manuscript on compliance with the StOP? protocol with the title: “Context and task-related factors influencing the compliance of surgical teams with an intra-operative briefing intervention”. Data from one hospital is not prepared yet, therefore missing in the current manuscript.

Context and task-related factors influencing the compliance of surgical teams with an intra-operative briefing intervention

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Abstract

Background: To enhance intra-operative information exchange, an intra-operative briefing, the StOP?-protocol, was introduced in the operation room. At crucial moments, the leading surgeon interrupts the surgery and informs the team using structured communication in terms of the current Status (St) and Objectives (O) of the surgery, possible upcoming Problems (P), and encourages other team members to ask questions (?). Literature on the surgical safety checklist suggests that potential positive effects of such interventions depend on compliance. Therefore, it is important to know factors which increase or decrease compliance.

Objective: To evaluate the level of compliance with the StOP?-protocol and what factors influence the compliance.

Methods: Introduction of the StOP?-protocol in four hospitals in Switzerland (9 months pre, 9 months post design). Compliance with the protocol was measured using a post-surgery questionnaire filled in by scrub nurses.

Results: Analyses of three hospitals[2] reveal a compliance in nurses reporting about the StOP?-protocol overall of 79.1%. Results show differences between hospitals, significantly higher compliance for elective surgeries, for longer surgeries, and for minimal invasive surgeries. The filled in reports show that at least one StOP?-protocol is carried out in 83.6% of the surgeries. Results show differences across hospitals and higher compliance for elective surgeries and for longer surgeries. There was no difference between minimal invasive and open surgeries.

Discussion: There are different possible factors influencing the compliance with the StOP?-protocol. In this study we could show that compliance with the StOP? is good, but compliance level depends on hospital and surgery characteristics.

[2] Data from one hospital are not yet available

Keywords: Surgical teams; medical teams; team intervention; compliance

Introduction[3]

Besides technical performance, good teamwork within interdisciplinary surgical teams is an important influence on surgical quality [1] [2] [3]. Recent studies found that more information exchange [4], and, specifically more task-relevant communication during surgeries, had a positive effect on patient outcomes [5]. More task-relevant information exchange may foster the development of a shared mental model [6] and may foster smooth cooperation.

To promote safety and information exchange within surgical teams, the World Health Organization (WHO) introduced preoperative checklists and briefings [7]; they have become standard in many hospitals [8]. However, positive effects on patients have only be reported if the surgical teams comply with the use of the checklist [9-12]. Since the introduction of the preoperative checklist, problems with compliance have been noted and remain a problem until nowadays [13].

Based on the experience with the preoperative checklist, it is likely that compliance might also be a problem if other team-based interventions are introduced for surgical teams. In this paper, we analyze influences on compliance after the introduction of a short briefing to be carried out by the surgical team during surgeries, called StOP?-briefing.

We first shortly present the StOP?-briefing intervention and how it was introduced in the participating surgical departments. Based on the preoperative checklist literature, we then give a short summary on known influences on compliance and discuss potential context- and task-related influences on compliance for the StOP?-briefing. We then present preliminary analyses of compliance in three (out of four) participating hospitals.

[3] This is an interdisciplinary study between medicine and psychology; we apply the citation rules of a medical journal.

The StOP?-Briefing

The StOP?-briefing is an intraoperative briefing procedure, initiated and led by the main surgeon. Its aim is to assure the specific exchange of task- and cooperation-relevant information and to encourage speaking up within the team [14]: At specific moments during the surgery (e.g., before critical phases, before strategy changes, after changes in OR personnel, before closing), the responsible surgeon pauses the surgery, summons all team members around the table, and informs the team about the current status of the surgery (St), the next steps and objectives (O), and about possible problems (P) and explicitly encourages team members to speak-up and ask questions (?). As surgeries differ in length and complexity, the moments to interrupt a surgery for the StOP?-briefing differ among procedures. Immediately after the WHO checklist procedure, the responsible surgeon announces when he or she plans to carry out a StOP?-briefing. Note that several StOP?-briefings may take place during a single procedure and that unforeseen changes during the procedure may trigger additional StOP?-briefings.

Influences on compliance for briefings in surgical teams and the current study

In this part, we discuss compliance issues regarding the introduction of interventions. We refer to research related to the introduction of the WHO checklist in surgical teams, but also literature related to interventions in teams in general.

When introducing a team intervention, it is essential that all team members comply and are going along with it. A low compliance can lead to failure of the intervention, even if the intervention, if applied, would work. Indeed, compliance of the surgical team was a prerequisite of positive effects of the preoperative surgical checklist [15, 16], and the efficacy of the checklist increased with increasing compliance [17]. Thus, when testing the effect of an intervention, compliance has to be assessed, as suboptimal compliance may lead to an

underestimation of the possible effects [18]. Lack of compliance and lack of effects also imply different remedies.

Research on checklist use in surgical teams suggests several influences on compliance. First, the intervention needs to be adapted to the specific environment; this is why the WHO encourages surgical departments to adapt their basic checklist [19-23]. Such adaptations should ensure that the process is reliable and assure that the intervention is easily embedded into existing work routines and is not disruptive [24]. Second, it is important that the intervention is not perceived as something imposed from outside; therefore, key people of the hospital should be involved in the initiation of the checklist [25], and the patron of the project should be a respected surgeon from the hospital [26]. All leaders should be fully convinced and actively support the intervention [21, 27-30]. Third, it is important to bring more than the leaders onboard. All staff, independent of their discipline [27], should be actively involved from the beginning; they should be encouraged to contribute their ideas and concerns [21, 25, 29]. This helps the staff to understand and accept the purpose of the intervention [13, 31]. Fourth, introduction and training play a crucial role in preparing the team for the change [27], and fifth, compliance and acceptance should be monitored over time; changes and developments should be evaluated, and constant feedback and, if necessary, re-training should be provided [21, 27, 29, 32].

Many of the above-mentioned factors can guide the way an implementation is introduced. With regard to the current study, the introduction of the StOP?-briefing followed these recommendations: The StOP?-intervention was developed and introduced by an interdisciplinary team of surgeons and psychologists, and the introduction was supported by all key surgeons, anaesthesiologists, and operating room nurses, which satisfies the criteria of involving key people. The procedure was adapted to each hospital as well as to the specific procedures, which satisfies adaptation to the local situation. Surgeons, anaesthesiologist,

scrub and circulating nurses were trained, and during the intervention period, feedback was provided by external observers.

However, in addition to the above-mentioned aspects, there are also contextual factors influencing compliance with briefings and other interventions in surgical teams, and these have received less attention. When implementing safety-related measures, the specific hospital culture has been found to play a role. Thus, compliance may be different across hospitals [22], although results with regard to such differences are mixed. A study by JJ Delgado Hurtado, X Jimenez, MA Penalonzo, C Villatoro, S de Izquierdo and M Cifuentes [33] suggests that private hospitals have higher compliance than public hospitals. Another study found higher compliance in general and teaching hospitals than in academic hospitals [34]. On the other hand, S Cullati, MJ Licker, P Francis, A Degiorgi, P Bezzola, DS Courvoisier and P Chopard [35] did not find any hospital-related differences in compliance. Another influence on compliance may be aspects of the surgical procedure. For example, checklist compliance was lower for more urgent patients requiring emergency procedures, than for scheduled, planned elective surgeries [16]. Additionally, compliance was higher in major, longer surgeries as compared to minor interventions [36].

Based on these considerations, we evaluate hospital- and surgery-related differences in compliance with the StOP?-procedure. Given previous research, we do not formulate a hypothesis concerning hospitals. For surgery-related influences, we expect that compliance is lower for emergency procedures and higher for longer, more complex procedures.

In addition to those factors, we also hypothesize that minimal invasive surgeries may have lower compliance than open surgeries. To the best of our knowledge, this aspect has not yet been examined as influence on compliance. In minimal invasive surgeries, the surgeons make only minor incisions and operate with the help of a camera that shows the operative field. TV screens in the operating room show not only the site but display the surgeon's actions in real time. Team members with an understanding of the anatomy and the procedure

may thus be informed about the process by following it on the screen. In this sense, the screen helps to foster a shared mental model. If a shared mental model can be established with other means, the team may find the StOP?-briefing less useful.

Methods

Design, Setting, and Sample

Data stem from an intervention study with a pre-post design following the logic of an interrupted time series; for this paper, we included surgeries during the nine-month intervention period. The study took place in the surgery departments of four Swiss hospitals, including the departments of general (visceral) surgery of two middle-sized university hospitals (Hospitals 1 and 2), of one middle-sized regional hospital (Hospital 3), and the department of general (visceral) and vascular surgery of a middle-sized urban hospital (Hospital 4). All elective and emergency procedures with general anesthesia in the participating departments were included. Exclusion criteria were previous surgery within the last 30 days, and a preexisting surgical site infection.

All patients gave consent that their data could be used for research, and ethical boards of the counties the hospitals are situated in approved the study.

Procedure

Training. Training for the StOP?-intervention included interviews with all main surgeons and selected staff, presentations, an instructional video and written information for all professions. Reminders in the operating room included wall-posters with instructions, as well as smaller posters on doors and at the hand-washing facilities. During the two-week training phase, observers were present during elective surgeries and provided on-site feedback, during the intervention phase, observers were present about twice a week. Monthly feedback was provided to surgeons and theatre nurses.

Immediately after each surgery, the scrub nurses were asked to fill in a compliance questionnaire consisting questions about the StOP?-briefing(s) for the surgery.

Measures

Eligible surgeries: Data for all eligible procedures were collected based on patient files by specially trained study nurses. Among other aspects not reported here, the database included date of surgery, urgency (emergency versus elective surgery), start and end time of the surgery, and surgical access (minimal invasive vs open). This database is used as base rate for assessing questionnaire compliance and documented compliance.

Compliance questionnaire: Scrub nurses filled in a post-surgical questionnaire containing questions about whether, and how often, a StOP?-briefing was carried out and other questions not reported here. If there was more than one scrub nurse present for a procedure, each scrub nurse filled in a questionnaire, for these surgeries, compliance was assumed if a briefing was marked in at least one questionnaire.

The information about the procedures done and the compliance questionnaire allows to calculate three types of compliance: (1) Reporting compliance measures whether a compliance questionnaire is available for a given surgery, (2) Contingent StOP? compliance measures whether at least one StOP? was done for a surgery a questionnaire is available, and (3) Documented StOP? compliance assesses whether a questionnaire with a documented StOP? is available for an eligible surgery. For instance, if questionnaires are available for 90 of 100 surgeries, Reporting compliance is 90%. If the StOP?-briefing was carried out in 72 (80%) of these 90 procedures, Contingent StOP? compliance is 80%. The 72 documented briefings represent 72% of the 100 surgeries, so the Documented StOP? compliance is 72%.

Urgency. Procedures were coded as (0) for emergency procedures and (1) for elective (planned) procedures. *Duration* of surgeries was measured from start to end of the surgery as documented in the patient file; it is expressed in hours. *Surgical access* was either minimal invasive (0) or open (1); surgeries starting as minimal invasive but later converted to open were coded as open surgeries.

Statistics

Descriptive statistics were computed for compliance measures and are reported as counts and percentages. To assess influences on compliance we conducted a binary logistic regression analysis for each of the three compliance measures. Hospital, urgency, and surgical access were included as categorical predictors, surgery duration as a continuous predictor. For all analyses, $P<.05$ was considered statistically significant. SPSS 25 software was used for all analyses [37].

Results

There were 3372 eligible surgeries during the nine-month intervention period (Hospital 1: 1171; Hospital 3: 663; Hospital 4: 1538).[4]

Reporting compliance. In 79.1% of the surgeries, a compliance questionnaire was available (Hospital 1: 81%; Hospital 3: 70%; Hospital 4: 81.7%). Results of the logistic regression analysis are presented in Table 1. Results show differences between hospitals, significantly higher compliance for elective surgeries, for longer surgeries, and for minimal invasive surgeries. Note that this compliance measure does not include whether a StOP?-briefing has been carried out but only whether a questionnaire is available for a surgery.

Since there are 3 hospital categories, hospital 1 was taken as contrast. Scrub nurses were more likely to fill in a questionnaire in hospital 1 than in hospital 3.

[4] Data from hospital 2 are not yet available

Table 1: Logistic Regression Analysis of Reporting Compliance

	Coeff./B	S.E.	p	Odds Ratio/Exp(B)	95% CI lower	95% CI upper
Hospital			.000			
3	-.640	.126	.000	.527	.412	.675
4	.211	.112	.058	1.235	.992	1.537
(base=1)						
Urgency (elective=1)	1.163	.097	.000	3.201	2.649	3.868
Duration in hours	.212	.038	.000	1.236	1.148	1.330
Surgical access (open=1)	-.324	.097	.001	.723	.598	.875

Contingent StOP? compliance. This compliance measure assesses how likely a StOP?-briefing was done for surgeries for which a questionnaire was available. In 83.6% of the questionnaires at least one StOP? was reported (Hospital 1: 86.9%; Hospital 3: 91.6%; Hospital 4: 78.2%). Results of the logistic regression analysis are presented in Table 2. The analysis shows differences in contingent compliance across hospitals. Again, hospital 1 was taken as base, contrasting the others against it. A StOP? was significantly more likely in hospital 3 compared to hospital 1, but significant less likely in hospital 4 than in hospital 1. A StOP? was more likely in elective surgeries and for longer surgeries, supporting the hypotheses. There was no difference between minimal invasive and open surgeries, contradicting our hypothesis.

Table 2: Logistic Regression Analysis of Contingent StOP? Compliance

	Coeff./B	S.E.	p	Odds Ratio/Exp(B)	95% CI lower	95% CI upper
Hospital			.000			
3	.552	.205	.007	1.737	1.162	2.597
4	-.462	.128	.000	.630	.490	.810
(base=1)						
Urgency (elective=1)	.519	.123	.000	1.681	1.321	2.139
Duration in hours	.239	.047	.000	1.270	1.158	1.392
Surgical access (open=1)	-.056	.120	.642	.942	.747	1.197

Documented StOP? compliance. This compliance measure compares documented StOP?-procedures against all eligible procedures. Documented compliance was 65% (Hospital 1: 70.4%; Hospital 3: 63%; Hospital 4: 62%). Results of the logistic regression analysis are presented in Table 3. Again, there were differences between hospitals in compliance. Compared to hospital 1, both hospitals 3 and 4 had a significantly lower documented compliance. A StOP?-procedure was more likely in elective surgeries and for longer surgeries, supporting the hypotheses. A StOP?-procedure was more likely for minimal invasive surgeries, contradicting our hypothesis.

Table 3: Logistic Regression Analysis of Documented Compliance

	Coeff./B	S.E.	p	Odds Ratio/Exp(B)	95% CI lower	95% CI upper
Hospital			.000			
3	-.304	.113	.007	.738	.591	.920
4	-.232	.092	.012	.793	.662	.950
(base=1)						
Urgency (elective=1)	.946	.084	.000	2.577	2.184	3.040
Duration in hours	.231	.031	.000	1.260	1.187	1.339
Surgical access (open=1)	-.236	.083	.004	.790	.672	.929

Discussion / Conclusions

We used three different compliance measures – Reporting compliance, which measures if a compliance questionnaire was provided; Contingent StOP? compliance, which is an estimation of compliance contingent on available compliance data; and Documented StOP? compliance, which is the most rigorous measure, because it only counts compliance if a questionnaire is available that documents compliance.

How compliance is measured and whether these measures are reliable is most often not addressed in compliance studies. In this study we could show that reporting compliance (whether the scrub nurses filled in a questionnaire or not), is biased and depends on hospital and surgery characteristics (see Table 1).

Contingent compliance and documented compliance both showed differences between hospitals. As compared to hospital 1, both analyses show significantly less compliance for hospital 4. As compared to hospital 1, however, contingent compliance is higher, but documented compliance is lower for hospital 3. Note that hospital 3 has a lower reporting compliance rate than hospital 1. It could thus well be that scrub nurses in hospital 3 were more likely to omit to fill in a questionnaire when the surgeons did not comply to the StOP?-briefing.

Contingent and documented compliance were higher for elective surgeries. Emergency procedures often are carried out under time pressure, and often during the night or the weekend. Both factors are possible reasons for people to fall back into routines existing before the intervention. While some emergency surgeries are relatively simple and fast procedures (e.g. appendectomies), others are more unpredictable, less plannable and especially complex. Besides falling back into old routines, surgeons may be less certain about the approach in emergency surgeries than in elective surgeries and thus less able to announce in advance when the StOP?-procedure should take place.

Contingent and documented compliance likelihood increased with surgery duration. It could be that for very short surgeries, the surgeon does not see the need for an update during the surgery because things are very clear. Longer surgeries include more critical steps and more likely have a strategy change; thus, updates for the shared mental model are more useful.

Interestingly, in documented compliance, a StOP?-procedure was more likely if the surgery was minimal invasive as compared to open procedures, contrary to our hypothesis. In minimal invasive procedures, all team members can potentially follow in real time what is happening during the surgery, which could contribute to a shared mental model and yield a StOP?-briefing less useful. Although speculative, there are several explanations for this effect. First, although displayed on the monitor, even minimal invasive surgeries may be hard to follow, because often, the anatomical structure of the patient is not entirely clear, given the reduced scope of the camera, limiting the broadcast's utility to foster a shared mental model. Second, not all members of the surgical team may have access to a screen. In some of the hospitals, the anaesthesiologists could not see the monitor from their position. Another explanation could be that it is easier for the surgeon to perform the StOP?-procedure if he or she can explain the status of the surgery using the monitor. Finally, the common knowledge effect could play a role [38]. It shows that information known to all team members is more likely to be discussed than unshared information. However, more research is needed to assess the information needs of a surgical team for minimal invasive and open surgeries.

Compliance rates for the StOP?-briefing range between 62% and 91%, depending on hospital and the compliance assessment used. Such compliance rates are similar as in studies on introducing the WHO checklist [39].

This study shows that contextual variables (hospital) and task-variables (emergency vs elective), complexity (duration), and surgical access influence compliance with a new briefing introduced into surgical teams. The study supports the importance of those variables as

influences on team behavior in surgery. A second important aspect of this study is that it also shows that measuring compliance itself can be influenced by contextual and task variables in such settings. Studies assessing compliance should thus also critically discuss their method of data collection of compliance.

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3.5 Manuscript on StOP? Influences on the Timeout

This chapter contains the paper on the Timeout with the title: “Two are better than one – Introducing an intra-operative briefing enhances the quality of an established pre-operative briefing: a pre-post intervention study”. The paper is ready, but feedback from co-authors are pending

Two are better than one – Introducing an intra-operative briefing enhances the quality of an established pre-operative briefing: a pre-post intervention study

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ABSTRACT

Background The team timeout is a generally established safety checklist to perform by the surgical team prior to each surgery. Besides of checking critical information, the timeout should also promote and support open communication during the operation.

To further improve the exchange of critical information, the StOP?-protocol was introduced: At critical moments during each procedure, the leading surgeon interrupted the surgery and informed the team in terms of the current Status (St) and Objectives (O) of the surgery, possible Problems (P), and encouraged questions of other team members (?).

Based on earlier findings that interventions that draw attention to team level may influence aspects of the team process beyond the targeted process, we investigated whether the introduction of the StOP?-protocol influenced timeout quality.

Methods This was a prospective intervention study employing a pre-post design. In the visceral surgical departments of two university hospitals the quality of 267 timeouts were assessed by external observers before (117) and after (150) the introduction of the StOP?-briefing. Timeout quality was rated in terms of timeout completeness (number of checklist items mentioned) and timeout quality (engagement, pace, social atmosphere, noise).

Results As compared to the baseline, after the implementation of the StOP?, observed timeouts had a higher completing rate ($F=16.60$, $p<0.001$) and were rated significantly higher in engagement ($F=18.43$, $p<0.001$), less rushed ($F=17.00$, $p<0.001$), in a better social atmosphere ($F=16.40$, $p<0.001$) and less noisy ($F=13.66$, $p<0.001$), according to observers.

Conclusion The StOP?-protocol does affect aspects of the timeout. However, it does not harm or interfere with the timeout goals; instead, it increases timeout completeness and quality of the team timeout.

INTRODUCTION

Besides technical and medical proficiency, teamwork within surgical teams has been identified as an important influence on surgical outcomes [1-5]. Therefore, interventions have been introduced that aim at fostering better teamwork in the operating room (OR) [5 6], often combining several interventions [6]. Although there are indications that different interventions may favorably influence one another [7], interferences are possible as well. However, it has rarely been investigated if, and how, several interventions mutually influence each other. This prospective observational study using a pre-post design tests the impact of the introduction of an intraoperative briefing (the StOP?-protocol) on an already existing briefing (the team timeout) in surgical departments of two different University hospitals.

The Team Timeout Checklist Intervention

In 2008, the World Health Organization (WHO) published a checklist-based briefing and suggested that surgical teams worldwide perform safety checks during the perioperative phase. One of the recommended briefings is the so-called team timeout (TTO), conducted at the time the anesthetized patient is already prepared in the OR, just before the incision. The TTO is performed by the entire surgical team. In Switzerland, the TTO is not mandatory by law, but it has been adopted by most hospitals [8]; both hospitals participating in this study introduced the TTO before 2011. Although the WHO has suggestions as to which aspects should be discussed during the TTO, it also recommends that the procedure should be adapted for each hospital; this indicates that cultural differences between hospitals may exist.

The main goal of the TTO is to exchange and double-check critical information in order to prevent errors (e.g. patient identity, planned procedure, status of antibiotics). The introduction of TTO has indeed been shown to reduce the rate of adverse events, patient morbidity and even mortality [9-13], although a recent large Canadian study did not replicate these effects [14]. In addition, studies report that the TTO had beneficial effects for the team. Surgical team members perceived collaboration and communication as improved after the

introduction of TTO [15-18], this was confirmed by an observational study that showed a significant decline of communication failures after the introduction of the TTO [19].

Positive effects of the TTO depend on its correct use, and this is not self-evident [20, 21]. Early studies reported reluctant adoption of the procedure, particularly by surgeons [22]. In current practice, incomplete TTO's can be observed [23], and often, surgical team members do not pay close attention to the TTO [24]. These are not harmless omissions, as the quality of TTO execution is related to its outcomes [23]: If boxes are ticked without paying attention, the risk of not detecting errors may actually increase [25], and a false sense of security may develop [20, 26]. Thus, participation and commitment by all team members is essential [10]. More specifically, team members should not engage in other tasks during TTO [27]. Furthermore, TTO may create a sense of time pressure. Although the typical TTO takes less than two minutes, some feel that TTO is taking too long, and they may start to hurry [28, 29]. This puts pressure on the team to finish rapidly, which not only leads to omitting information [30 29, 31], but can create a sense of urgency that can lead to tensions. A tense atmosphere during the TTO has been found to lead to dismissive communication later on [29] and to impair the collaborative process throughout the surgery [25, 32].

The StOP? – Intervention

Despite the information exchanged during TTO, one of the main complaints of members of the surgical team is that they feel under-informed by the operating surgeon about the progress, about the specific strategic approach and, particularly, about strategy changes during the procedure [33]. The exchange of task-related information is indeed important during surgeries: more information exchange [3] and specifically more case-relevant communication during surgeries have been shown to be related to better patient outcomes [34].

Surgeons are not simply unwilling to share information with the team. Performing surgery requires high concentration, often on manual aspects of the task [35], and surgeries can be quite stressful for the surgeon [36]. Both aspects can impair communication and high

concentration requirements on manual tasks may inhibit the surgeon to focus on the team's information needs, which constitute a task in its own right [37, 38]; and it is well known that team members tend to lose the team perspective when stressed [39].

To foster intrasurgical information flow, mainly, but not exclusively from the surgeons towards the team, we developed an intervention aimed at assuring the exchange of task- and cooperation-relevant information. The StOP? is an intraoperative briefing, initiated and led by the responsible surgeon. Its aim is to inform all team members about the progress of the surgery (**St** = provide information about the status of the surgery), about next steps and proximal goals (**O** = inform about next objectives), and about potentially expected problems and difficulties (**P** = inform about potential problems), and at encouraging team members to voice their observations or to ask questions (**?** = explicitly encourage team members to speak up).

The structure of the StOP?-intervention resembles other briefing interventions [40-42], but two aspects make it particular. First, the briefing does not take place at fixed moments during surgeries, but is adapted to the specific task and the situation. Tasks often have natural breakpoints. Such breakpoints occur after the completion of a subtask and before the next subtask starts. When shifting from one subtask to another, the concentration requirement for specific aspects of the task is temporally reduced, and at this time it is easier to switch attention to the team level. Therefore, surgeons are encouraged to initiate the StOP?-protocol at moments during surgeries when a natural break occurs, and particularly before a strategy change is induced. As more than one StOP?-briefing is possible per surgery, surgeons announce, at the end of the TTO and before the incision, when they intend to do a StOP?-briefing. The second particularity of the StOP? intervention is that transmission of information by the surgeon is followed by an explicit request by the surgeon to the team to speak up [43, 44].

Can one intervention influence another?

Both inhibiting and enhancing mutual influences of several interventions seem possible. On the one hand, adding and combining several interventions may lead to feelings of overload or overregulation, which may create resentments, or may reduce the attention to each single intervention, as people may perceive redundancy [45] and develop an attitude akin to "checklist fatigue" [46].

On the other hand, interventions may enhance each other's effects. Within a laboratory setting, Okhuysen and Eisenhardt (2002) explored how simple interventions to foster cooperation improve knowledge integration in groups. One interesting finding of their study was that each of three different interventions did not only increase the instructed behavior, but spilled over to increase the use of other cooperative strategies that were not explicitly instructed. The authors concluded that even simple interventions influence cooperation when they direct the attention to the team-level, and this independently of the specific strategy that was encouraged. They see the interventions as "windows of opportunity" to switch the attention from the task to the team level and to implement cooperative strategies.

As timeout and StOP? do not overlap very much in terms of content, we contend that the StOP?-briefing constitutes such a window of opportunity and hypothesize that the StOP?-briefing influences the team process beyond the time the briefing takes place.

Research QuestionS

Primary endpoint of this study is the quality of the TTO before and after the StOP? briefing was introduced in surgical teams, as assessed by trained observers.

A secondary research questions is to evaluate cultural differences between participating hospitals in the quality of TTO as well as the effect of the StOP? intervention on the TTO.

METHODS

Study Design, Setting, and Sample

This was a prospective intervention study employing a pre-post design. We compared team timeout quality in surgeries performed before and after the introduction of the StOP? briefing, with each assessment period lasting nine months.

The study took place in the general surgery departments of two middle-sized Swiss University Hospitals. Inclusion criteria were elective general surgeries with an expected duration of more than one hour and the availability of the observers. Exclusion criteria were a preexisting surgical site infection (e.g. re-surgery after the patient suffered an infection) or another surgery within the last 30 days.

A total of 271 surgeries were observed; observation of TTO was possible for 267 surgeries (Hospital A: 76 surgeries during baseline / 73 during the intervention period; Hospital B: 41 surgeries during baseline / 77 during the intervention period). We strived to observe a typical mix of surgeries during the baseline period. During the intervention period, we aimed at matching the proportion of the different surgical types observed during baseline. Comparing the proportion of observed surgery types before and after the intervention yielded no significant differences, indicating successful matching (see TABLE 1).

TABLE 1: Demographics

		Hospital A		Hospital B	
		Baseline	Intervention	Baseline	Intervention
N		76	75	43	77
Patient Age		58.41	58.55	56.02	62.32
Sex	Male	43	49	25	41
	Female	33	26	18	36
Type of surgery					
	Upper GI tract	7	8	4	7
	Lower GI tract	11	12	9	16
	Liver	16	13	7	11
	Pancreas	16	15	7	10
	Hernia	4	4	1	6
	Cholecystectomy	4	3	4	12
	Gastric bypass/sleeve	6	5	6	6
	Kidney transplants	8	8	2	3
	Sarcoma			1	2
	Other	4	7	2	4
Chi2			1.46 (df=8, p=.99)		3.63 (df=9, p=.93)

Study procedure

All surgeries were observed in vivo by trained observers present in the OR. The TTO was observed according to a checklist on a tablet computer. All members of the surgical team were aware of the observations. However, neither the members of the surgical team nor the members of the observational team were aware of the research question.

The study was approved by the ethics committees responsible for each of the hospitals; the members of the surgical team were informed about the study and consented via an opt-out process.

Outcome Measures

Team timeout completeness

TTO procedures were different in Hospital A and B. In Hospital A, the TTO comprised of eleven mandatory items to discuss. The TTO was initiated and led by the circulating nurse who read out aloud each of the questions. Responses were provided by the person responsible for the respective information (e.g. the anesthesiologist for allergies, the surgeon for potential blood loss, the scrub nurse for instruments). In Hospital B, the TTO was initiated by the responsible surgeon and was held predominantly between the surgeon and anesthesiologists. Of the six items on the checklist, only two were mandatory (patient identity and planned procedure), the rest was mentioned if considered relevant by the surgeon or anesthetists.

TTO completeness for Hospital A was the proportion of the eleven mandatory items discussed. For Hospital B, we calculated two completeness scores; one related to the two mandatory items (0, 0.5 or 1), and one expressed as proportion of all six items on the list (all items). If an observer did not hear a timeout well enough to declare if an item was mentioned or not, the data for this item was coded as missing, scores were only calculated if there were data for every item.

Team timeout quality

The quality of the team timeout was measured by an instrument based on earlier research and adapted for this study [25, 45, 47, 48]. In addition to factual aspects of the TTO (e.g. who was present, who initiated it), which are not reported here, four components of TTO quality were rated by the observers: **Engagement** during TTO was assessed using a 5-point Likert scale ranging from not committed (1) to committed (5); **Pace** of the TTO was assessed using a 5-point Likert scale ranging from rushed (1) to calm (5); **Social climate** was assessed using a 5-point Likert scale ranging from irritated (1) to serene (5); **Noisy conditions** was assessed using a 5-poing Likert scale ranging from no noise (1) to very noisy (5).

All of the quality components observed were combined into a quality index (the item about the noisy conditions was reversed), which yielded an index with good internal consistency (Cronbach's $\alpha = 0.723$).

About 9.4% (N=25) of the observed TTO were assessed by two independent observers. Intra class correlation (ICC) was calculated to assess inter-observer agreement and yielded good results (engagement: ICC=0.768; pace: ICC=0.845; social climate: ICC=0.742 and noise: ICC=0.899).

Statistics

Descriptive statistics are reported as means and standard deviations or counts and percentages for categorical variables. To compare TTO quality before and after the intervention across the hospitals, we conducted 2x2 factorial ANOVA's, with the StOP?-intervention (before, after) and the hospital (Hospital A, Hospital B) as fixed factors. Pairwise comparisons (before and after the intervention and between the hospitals) were assessed based on estimated marginal means and were Bonferroni adjusted; differences in the change rate between hospitals were assessed by an intervention x hospital interaction effect. Interobserver reliability was assessed with Intraclass correlation (ICC). P less than 0.05 was considered statistically significant. We used SPSS 25 for all analyses [49].

RESULTS

Team timeout completeness

Descriptive statistics and ANOVA results are displayed in Table 2. Analyses show a positive effect of the StOP? intervention on TTO completeness for all items as well as for the mandatory items (TABLE 2, line “Intervention”). However, for completeness of all items, the effect of the intervention is qualified by the increase in completeness after the StOP-intervention in Hospital B, but not in Hospital A. Overall, TTO completeness was significantly higher in Hospital A than in Hospital B, for all items as well as for the mandatory items.

TABLE 2: **Timeout Completeness** (all items / mandatory items) before and after the StOP?-intervention and between hospitals

Completness TTO (all items)										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference** intervention –baseline (SE)	95% CI for difference	F	P
Model									51.64	<0.001
Interven-tion	261	0.90(0.18)	114	0.88(0.20)	147	0.91(0.17)	0.078(0.02)	0.04 to 0.12	16.60	<0.001
Hospital A	149	0.99(0.04)	76	0.99(0.05)	73	1.00(0.01)				
Hospital B	112	0.78(0.23)	38	0.68(0.24)	74	0.83(0.21)				
							Difference** Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.24(0.02)	0.20 to 0.27	151.3	<0.001
Intervention x Hospital									11.93	0.001
Completness TTO (mandatory items)										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference** intervention –baseline (SE)	95% CI for difference	F	P
Model									3.931	0.009
Interven-tion	265	0.97(0.14)	115	0.96(0.16)	150	0.98(0.12)	0.035(0.017)	0.00 to 0.07	3.970	0.047
Hospital A	149	0.99(0.04)	76	0.99(0.51)	73	1.00(0.10)				
Hospital B	112	0.95(0.20)	39	0.91(0.25)	77	0.97(0.16)				
							Difference** Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.54(0.02)	0.02 to 0.09	9.64	0.002
Intervention x Hospital									1.71	0.19

* Completeness scores are shown as proportions

** Based on estimated marginal means;

Team timeout quality

Descriptive statistics and ANOVA results are displayed in TABLES 3 and 4 and illustrated in FIGURE 1.

Analyses show a positive effect of the StOP? intervention on TTO quality measured by the combined quality index (TABLES 3, lines "Intervention"). Separate analyses for the single quality components showed that the introduction of the StOP? was related to a mean increase of engagement of $\beta = 0.60$ points on the 5-point scale; a mean increase of quality related to pace of $\beta = 0.70$ on the 5-point scale; a mean increase in quality of social climate of $\beta = 0.55$ points on the 5-point scale; and a mean decrease in noise during the TTO of $\beta = -0.55$ points on the 5-point scale.

Analyses related to the secondary research question showed that TTO quality in Hospital A was significantly higher than in Hospital B before, but also after the intervention for the combined quality index, as well as for the quality components engagement, pace, social climate and noise (line "between hospitals" in TABLES 3 and 4). The StOP? intervention did not have a different impact on Hospital A or B, as evidenced by the non significant interaction effects (line "intervention x hospital" in TABLES 3 and 4) .

TABLE 3. Quality Index TTO before and after the StOP?-intervention and between Hospitals

Quality index TTO*										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference** intervention –baseline (SE)	95% CI for difference	F	P
Model									40.04	<0.001
Interven-tion	267	3.93(0.17)	117	3.74(0.76)	150	4.07(0.73)	0.48 (0.08)	0.31-0.63	34.62	<0.001
Hospital A	149	4.25(0.59)	76	4.08(0.59)	73	4.43(0.54)				
Hospital B	118	3.53(0.77)	41	3.13(0.68)	77	3.53(0.76)				
							Difference* Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.82(0.08)	0.66-0.98	103.0	<0.001
Intervention x Hospital									2.33	0.128

* The quality index is the mean of engagement, pace, social atmosphere and (reversed) noise, range from 1 to 5

** Based on estimated marginal means;

TABLE 4. Quality of TTO for the quality components engagement, pace, social climate and noise before and after the StOP?-intervention and between Hospitals

Engagement during TTO										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference* intervention –baseline (SE)	95% CI for difference	F	P
Model									21.05	<0.001
Interven-tion	267	3.81(1.01)	117	3.62(1.02)	150	3.96(1.01)	0.50(0.12)	0.27 to 0.72	18.43	<0.001
Hospital A	149	4.41(0.74)	76	3.95 (0.73)	73	4.34 (0.63)				
Hospital B	118	3.39(1.15)	41	3.00 (1.18)	77	3.62 (1.08)				
							Difference* Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.85(0.12)	0.62-1.07	53.61	<0.001
Intervention x Hospital									0.77	0.38

Pace of TTO										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference* intervention –baseline (SE)	95% CI for difference	F	P
Model									13.57	<0.001
Interven-tion	267	3.79(1.14)	117	3.56(1.18)	150	3.97(1.09)	0.56	0.29 to0.83	17.00	<0.001
Hospital A	149	4.07(1.01)	76	3.87(1.06)	73	4.29(0.92)				
Hospital B	118	3.43(1.14)	41	2.98(1.17)	77	3.68(1.15)				
							Difference* Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.75	0.49 to 1.02	30.77	<0.001
Intervention x Hospital									1.07	0.302

cont on next page

TABLE 4 - cont.

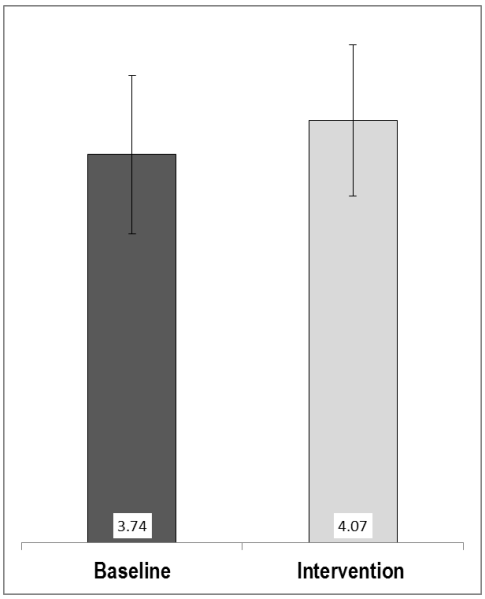
Social climate TTO										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference* intervention –baseline (SE)	95% CI for difference	F	P
Model									8.23	<0.001
Interven-tion	267	4.22(0.80)	117	4.03(0.84)	150	4.37(0.82)	0.418(0.10)	0.21 to 0.62	16.40	<0.001
Hospital A	149	4.35(0.80)	76	4.21(0.81)	73	4.49(0.77)				
Hospital B	118	4.07(0.88)	41	4.03(0.84)	77	4.37(0.82)				
							Difference* Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							0.37(0.10)	0.17 to 5.71	12.76	<0.001
Intervention x Hospital									1.71	0.192

Noise during TTO**										
	Total		**Baseline**		**Intervention**					
	N	M(SD)	N	M(SD)	N	M(SD)	Difference* intervention –baseline (SE)	95% CI for difference	F	P
Model									43.89	<0.001
Interven-tion	267	2.10(1.21)	117	2.21(1.14)	150	2.01(1.09)	-0.43(0.12)	-0.66 to -0.20	13.66	<0.001
Hospital A	149	1.56(0.78)	76	1.71(0.88)	73	1.40(0.64)				
Hospital B	118	2.79(1.11)	41	3.15(0.99)	77	2.60(1.13)				
							Difference* Hospital A – Hospital B	95% CI for difference	F	P
Between Hospitals							-1.32(0.12)	-1.44 to -1.09	127.7	<0.001
Intervention x Hospital									1.02	0.313

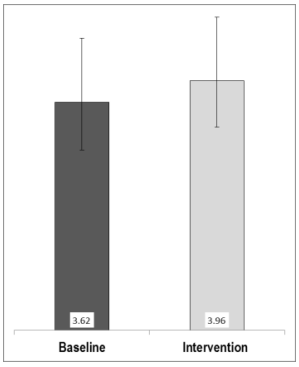
* Based on estimated marginal means;

**less noise indicates better quality

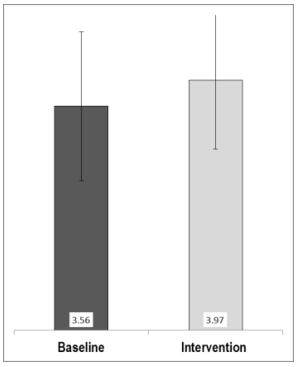
FIGURE 1 – Timeout quality index; engagement, pace, social climate and noise before and after StOP?-intervention. Whiskers represent +/- 1 Standard deviation.



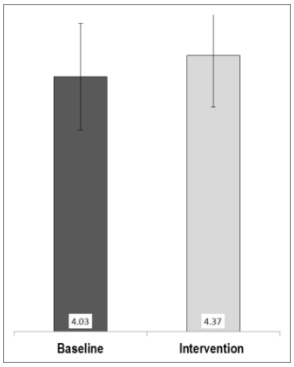
Timeout quality index
P<0.001



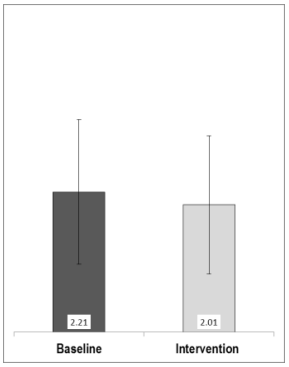
Engagement
P<0.001



Pace
P<0.001



Social Climate
P<0.001



Noise
P<0.001

Timeout quality components

DISCUSSION

The introduction of the StOP? briefing in two hospitals that had already established the TTO improved the quality of the TTO in terms of completeness, engagement, pace, social climate and noise conditions. Thus, the StOP?-intervention does affect the TTO in a positive way, and the additional briefing does not harm the already established briefing.

These results are consistent with the findings by Okhuysen and Eisenhardt [7] in a completely different field, and are also consistent with a recent finding on effects of team training interventions on the quality of TTO [6]. One explanation for this effect is indeed that additional interventions open the opportunity for teams to switch their attention to the team level, and thus influence cooperative behavior beyond the specifically targeted intervention. The effect could be due to momentary effects, in that anticipating the StOP?-briefing enhances the overall attention of the team. However, it could also be due to a more general effect. Through the information and training for the StOP? intervention, as well as the regular refresher trainings, the team members were reminded about the importance of information exchange and collaboration in the OR. Considering this possible connection, other kinds of interventions could have a similar effect on the timeout as long they are aimed at the team level [6].

Although the influence of the StOP?-intervention on the TTO emerged in both participating hospitals, TTO quality in Hospital B was lower overall than hospital A, before, but also after the introduction of the StOP?-protocol. It is well known that hospital-specific cultures exist, such cultural differences could be a reason for the differences in TTO quality between the Hospitals [50, 51]. Interestingly, the increase in TTO quality did not differ between hospitals, this is, Hospital B did not profit more from the StOP?- intervention than Hospital A. This indicates that the StOP? intervention influences TTO quality on every level.

There was, however, one exception: Hospital B increased the completeness of potential items discussed during the TTO more than Hospital A did. This is possibly due to

the fact that all items are mandatory in Hospital A, and that the initial TTO completeness of Hospital A was more than 97%. However, as the TTO rules for Hospital B stipulate that non-mandatory items should be discussed when relevant, the increase in discussed items in Hospital B points to a different appreciation of relevancy of items to discuss after the intervention. An alternative explanation could be a substantial change of surgeries observed during the intervention period - before complicated surgeries, TTO completeness is known to increase [25]. Although this explanation cannot be excluded, the proportion of the different types of surgeries observed before and after the intervention was very similar in both hospitals.

There was concern that the StOP? briefing might harm the TTO, because it could lead to perceived redundancy or lead to checklist fatigue [46]. Some degree of redundancy is generally favored in healthcare, because redundancy in the system increases safety [52], potential failures can be reduced if important information is checked multiple times and by different persons. But too much redundancy can also lead people to skip information checking, if they feel they already checked it often enough [45, 53]. The StOP?-intervention not leading to perceived redundancy could be due only one additional briefing not being enough to lead to a feeling of an overload. But it could also be that the StOP?-intervention addresses other kinds of information than the initial timeout and is therefore not perceived as "another checklist", but as the exchange of task- and cooperation relevant information about the procedure and strategy changes. It is not time consuming to perform, simple to follow and it facilitates communication among the members of the team, [54]. In addition, surgeons chose the moments for the StOP? intervention according to the phases or strategy changes in specific procedures – they thus adapted the intervention to the coordination requirements of the task This study has limits. As compared with the number of surgeries performed in both hospitals, the sample size is relatively low. Both observed surgical departments are specialized in general and visceral surgery, which limits the generalizability of the results. Another

limitation is that random assignment is not an option for this type of intervention, so a pre-post design had to be employed. Participants and observers were also aware of the intervention, however, neither the surgical teams nor the observers were aware of the specific research question.

This study has practical implications. It showed that the already established TTO benefited from another briefing intervention. Although TTO have known positive effects on team collaboration [19, 55, 56], their scope and purpose are limited, and additional interventions fostering information exchange can be beneficial [6] , and at the same time improving the quality of established briefings.

ACKNOWLEDGEMENTS

This research was funded by the Swiss National Science Foundation, #156882 , and a grant by the Bosch Foundation.

Acknowledgements: We thank Raffael Bittel, Anne-Sophie Brandt, Paola Cubillos, Margaux Grund, Ysaline Hug, Céline Lui, Paola Paaz, Gabriela Schenker and Annkathrin Schmidli, for their help in observations; Catherine Blanc, Nicolas Croxatto, Brigitte Dubach, Claudine Fanton, Uwe Klopsch, and Francois Marguet for their support for logistical and organizational aspects of the study.

None of the authors declares a conflict of interest.

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3.6 Manuscript on StOP? Influences on the Surgical Team

This chapter contains the manuscript on StOP? influences on the surgical team in the operating room with the title: “Supporting situation awareness and ease of speaking up by a short intervention to foster information exchange during surgical procedures: An intervention study”. The paper is ready, but feedback from co-authors are pending

Supporting situation awareness and ease of speaking up by a short intervention to foster information exchange during surgical procedures: An intervention study

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Keywords: surgery, teamwork, quality improvement, patient safety

ABSTRACT

Background: Team situation awareness, a shared understanding of an ongoing situation, is a prerequisite of good surgical team performance. Such a shared understanding needs to be updated and maintained throughout the task, which is done by communicating task-relevant information during surgery. To foster such communication, an intraoperative briefing was introduced. At critical moments during each procedure, the leading surgeon interrupted the surgery to do a StOP? – informing the team in terms of the current Status (St), Objectives (O), Problems (P), and providing a speak up opportunity by encouraging other team members to ask questions (?).

Goals: To compare situation awareness and ease of speaking up of surgical team members during surgeries before and after the introduction of an intraoperative briefing aimed at sharing relevant information within the surgical team.

Methods: Assessment of situation awareness and ease of speaking up of residents, scrub nurses, anesthesia care providers and circulators before and after the interventions across three hospitals, using 2x3 ancova with operative access and difficulty of surgery as covariates.

Results: Self-reports of 371 surgeries, 165 before and 206 after the intervention were analysed. The intervention improved situation awareness for anesthesia care providers and circulators, and ease of speaking up for scrub nurses, anesthesia care providers and circulators. No differences were found for residents.

Conclusion: The introduction of a short, intraoperative briefing enhances situation awareness of the surgical team members not directly working at the operation table. The possibility to express oneself at the end of the StOP? increases the ease of speaking up for team members.

INTRODUCTION

High situation awareness as prerequisite of surgical team performance.

High surgical team performance depends on technical as well as non-technical skills of all team members of the interdisciplinary team in the OR [4]. Besides technical difficulties, problems with cooperation and communication can lead to longer procedures [5, 6], more errors and lower technical performance [7-11], and more conflict within the OR team [12], potentially threatening patient safety [13, 14].

One important condition of good team performance evidenced from other fields [15-18], but also from research in surgery [19], is team situation awareness. Situation awareness is described as the team having a shared understanding or a shared mental representation of the task and its context, including its dynamic, changing aspects [1-3]. High situation awareness allows team members to cooperate better, because they can anticipate developments and prepare their own contributions accordingly.

Although most surgical procedures have standardized steps known to most, if not all, members of the surgical team, the specific strategic approach for a surgery may change during the procedure to adapt to actual conditions. Unforeseeable problems may require very rapid adaptation [20]. To maintain high situational awareness, it is thus important that the team members have access to information about the progress of the task, potential problems, and particularly about strategic changes and adaptations; this information needs to be updated throughout the process. The typical strategy to ensure situation awareness is communication and updating task-relevant information prior and during teamwork [21, 22].

In surgery, the primary surgeon is responsible for planning, strategy changes and in-task adaptations and is also the leader of the surgical team [23, 24]. The primary surgeon thus may hold information that is not known to the other team members. Based on good knowledge of the task, team members may be able to infer some of this information. However, most likely communication by the primary surgeon will be required to optimize

situation awareness. Supporting this argument, previous research showed that more information exchange during surgeries [25], and, more specifically, more task-related communication during surgery [26] are related to better patient outcomes.

Communicating task-relevant information during surgery often does not occur as a matter of course [27]; and it may be particularly difficult for the primary surgeon for three reasons. First, attentional capacity is limited. In surgery, the core task (the surgery itself) is often carried out by the primary surgeon who performs many of the difficult sensory-motoric tasks, those require full attention. Surgeons thus need to divide their attentional resources between several aspects of the surgery (psychomotor performance, operative judgment and decision making, dealing with distractions, and providing information to the other team-members) [20, 28, 29]. Communicating updates to the team consumes attentional resources that may interfere with the concentration needed to perform the surgery proper. Second, smooth psychomotor work can be a pleasant work experience (the so called flow experience) [30], characterized by a challenging, but manageable task and the possibility to intensely focus on the given activity. If the activity provides this optimal experience of flow for a surgeon, communicating and informing the team may be seen as a having to perform a disruptive and unpleasant activity[31]. Third, surgeons may not see the need for providing more information. A recent study showed that surgeons systematically underestimate the need for communication and overestimate situation awareness of the surgical team [32]. This can be particularly problematic in the OR, where steep hierarchies may prevent team members to actively seek information by asking questions or voicing concerns[33, 34]. It can therefore be necessary to support task-related information exchange during surgeries.

Intraoperative briefing to inform and update the surgical team (StOP?)

Based on the above considerations, a team of surgeons and work psychologists developed an intervention aimed at fostering information updates during surgeries. The StOP? intervention is an intraoperative short briefing performed at crucial points during surgical procedures.

The four elements of the StOP?-briefing require the surgeon a) to inform all team members about the actual state of the surgery (St – Status); b) to communicate the main objectives for the next phases - including strategy changes and expected remaining time (O – objectives); c) to point out potential problems that the team should be prepared for (P – Problems). After providing information, the surgeon d) encourages team members to speak up or ask questions (? – request questions). To initiate the StOP?-briefing, the surgeon interrupts the procedure and summons the whole team, including anesthesia care providers and circulators. To avoid attentional overload of the primary surgeon and untimely interruptions of the surgical procedure, the timing of the briefing is adapted to each surgery and takes place at natural breakpoints of the task - for example, before a critical phase; before a strategy change is implemented; when the responsible surgeon changes; after the last linen count before starting wound closure. As all team members interrupt their work during the briefing, cognitive overload of continuing psychomotor work while engaging in information exchange is limited.

Study aims

The Study is based on the hypothesis that structured communication during surgeries positively influences situation awareness of the members of the surgical team. **Primary aim** of this study is to compare situation awareness of surgical team members before and after the introduction of a novel briefing based on the acronym StOP?.

A multicentric prospective study was performed using a before and after design with a nine month baseline, one month of training and nine months of intervention.

Control variables were included to take into account additional factors that may influence situation awareness: First, the effect of the briefing may be different for team members who directly work at the table and those who are more remote (anesthesia care providers and circulators), because the latter have limited direct observational access to the surgical field and the surgeon's acts. Second, different hospital cultures may play a role, and finally, more difficult surgeries may entail more strategy changes which may impede situational awareness of the team members. In addition, the ease of access to surgical information may influence situation awareness in the sense that laparoscopic surgeries provide more direct information to all team members than open surgeries, and that situation awareness is lower in difficult surgeries.

Secondary aim of this study is to compare self-assessed ease of speaking up of surgical team members after the introduction of the StOP?-briefing. Speaking up has been described as voicing ideas, questions or concerns in a team [35, 36], and has been shown to contribute to preventing mistakes and to identifying and correcting errors [35]. However, many team members are reluctant to speak up, because voicing concerns bears interpersonal risks [37-39]. The StOP?-briefing addresses this problem: At the end of the briefing, the surgeon explicitly invites team members to share questions and thoughts.

Methods

Study design and Sample.

This multisite observational pre-post intervention study took place in the department of general (visceral) surgery of two European University hospitals (Hospital 1 and 2) and in the department of general (visceral) and vascular surgery of an urban hospital (Hospital 3), all attending and fellow surgeons agreed to participate. All hospitals offered surgery residency and fellowship programs. Ethical approval was given by the respective state ethical boards as part of the leading state ethical approval (KEK-BE #161/2014).

Data were collected for 165 procedures during the nine-month baseline period and for 206 surgeries during the nine-month intervention period. Inclusion criteria were elective surgeries typically performed in a participating department. Surgeries were chosen based on the surgery schedules and the availability of observers. There were no significant differences with regard to the type of surgeries before and after the intervention (Table 1).

Before the baseline measure, all surgical team members were informed about the study without details of the intervention. Training for the StOP?-briefing took place during one month after the baseline was finished. Training included presentations, leaflets, and an instructional video for all professions (surgeons, scrub nurses, circulating nurses and anesthesia personnel), as well as guided interviews with attending and fellow surgeons aimed at determining the optimal moments for StOP?-briefings for the surgeries most often performed by the respective surgeon. Posters on doors, at the hand-washing facilities, and in each operating room reminded all team-members about the intervention. During the training period, trained observers were present during all day surgeries, to provide on-site feedback; no data were collected during this period. After the training period, the intervention was introduced. Monthly reminders were sent to the surgical and the nursing team during the intervention period.

Data collection

For the 371 surgeries, an external researcher was present during the whole surgery. The researcher handed out a questionnaire to each of the surgical team members before he or she left the operating theatre and handed a questionnaire to anesthesia care providers shortly before the end of the surgery. Individual consent was assured by an opt-out procedure and confirmed at handing over the questionnaire. To assure confidentiality, the observers collected the questionnaires directly from the respondent and demographic information beyond the work-role was not collected.

Questionnaires were collected from all scrub nurses and circulators participating in a given surgery, provided they stayed for at least 15 minutes. The answers were averaged within role. Response rate was 99.5% for scrub nurses; 99.2% for circulators. Response rate for residents was 93.1%. Anesthesia care providers included anesthesiologists or anesthetists, dependent on who was available for responding to the questions; response rate was 99.2%.

Measures

Situational awareness was measured using two questions: "To what extent were you always informed about the plans and strategies the surgeons had in mind for this surgery?" "To what extend were you always informed about what the surgeons were doing at the very moment?" Answers ranged from (1) *absolutely not informed* to (7) *completely informed*. The two questions were combined into an index; Cronbach's alpha was 0.87, 0.88, 0.86, and 0.92 for residents, scrub nurses, anesthesia care providers and circulators, respectively; indicating good internal consistency.

Ease of speaking up was measured with one question "During this surgery, was it / would it have been possible for you at any time to ask questions or point out problems?". Answers ranged from (1) *without any hesitation* to (7) *with a great deal of hesitation*. For analyses, we reversed the question so that higher numbers represent higher ease of speaking up.

Difficulty of surgery measure was provided by the primary surgeon as answer to the following question "How challenging was this surgery for you?". Answers ranged from 1 (very easy, routine) to 7 (very challenging). The response rate for this question was 98.9%.

We coded *operative approach* as either minimally-invasive (laparoscopic) or open (laparotomies); surgeries that were converted from laparoscopic to open were coded as laparotomies.

Data analyses

Data were analyzed using SPSS 25 software [40]. Internal consistency was measured using Cronbach's alpha [41]. Descriptive statistics (means and standard deviations, percentages) were computed for all measures. For differences in the number of procedures before and during the intervention as well as difference in operative access, Chi-square were performed; differences in difficulty reported by the primary surgeon were tested by Analysis of Variance (ANOVA). To evaluate differences in situation awareness and in ease of speaking up before and during the intervention, we performed Analyses of Covariance (ANCOVA) for each occupational group (residents, scrub nurses, anesthesia care providers, and circulators). In all these analyses, hospital was included as a factor, and operative approach and difficulty (as reported by the primary surgeon) as covariates. All post-hoc tests results were Bonferroni-corrected. The direction of the association between control variables and outcomes was assessed using bivariate correlations. For all analyses, statistical significance level was set at $P<0.05$.

Results

A comparison of the types of surgeries included at baseline and during the intervention showed no significant difference, indicating that the case mix was similar (Table 1).

Difficulty as reported by the primary surgeon were similar at baseline and during the intervention, but there were significant differences in difficulty between hospitals ($F(2) = 5.139$, $P=0.006$). Post-hoc comparisons (Bonferroni corrected) reveal that difficulty was significantly higher ($P=0.006$) in hospital 2 than in hospital 3; with no significant differences between hospital 1 and 2 ($P=1.0$) or 1 and 3 ($P=0.051$), see Table 2. Overall, about half the surgeries were done using minimally-invasive approach. A lower percentage of surgeries were laparoscopic in hospital 1 than in hospital 2 ($Chi^2(1) = 12.67$, $P<0.001$) or in 3 ($Chi^2(1) = 17.86$, $P<0.001$); there was no significant difference between hospital 2 and 3 ($Chi^2(1) = 0.667$, $P=0.414$).

Table 1: Types of surgeries during baseline and intervention.

Surgery type	Hospital 1			Hospital 2			Hospital 3			
	Baseline	Inter-vention	Total	Baseline	Inter-vention	Total	Baseline	Inter-vention	Total	overall
Upper GI tract	7	8	15	4	7	11	2	2	4	30
Lower GI tract	11	12	23	9	16	25	5	11	16	64
Liver	16	13	29	7	11	18	1	2	3	50
Pancreas	16	14	30	7	10	17	3	3	6	53
Hernia	4	4	8	1	7	8	12	11	23	39
Cholecystectomy	4	4	8	4	12	16	7	8	15	39
Gastric bypass or gastric sleeve	6	5	11	6	6	12	4	4	8	31
Kidney transplants	8	8	16	0	1	1	-	-	-	17
Thoracoscopy	-	-		-	-	-	5	6	11	11
Vascular surgery	-	-		-	-	-	4	6	10	10
Other	4	7	11	5	7	12	3	1	4	27
TOTAL	76	75	151	43	77	120	46	54	100	**371**
Chisquare test	1.456			4.780			3.567			2.832
degrees of Freedom	8			8			9			10
P-Value	0.993			0.781			0.938			0.985

Note: N= 371 surgeries. Overall Chi2 (df =10) = 2.832, P=0.985; indicates no significant difference in surgical type between baseline and intervention

Table2: Descriptive statistics of difficulty assessment of the primary surgeon and operative access before and after the StOP?-Intervention across hospitals

	Hospital 1			Hospital 2			Hospital 3			Overall
	Base-line	Inter-vention	Total	Base-line	Inter-vention	Total	Base-line	Inter-vention	Total	
Difficulty of the procedure (rated by primary surgeon) (M, SD)[1]	4.37(1.54)	4.43(1.46)	*4.40(1.50)*	4.70(1.68)	4.52(1.69)	*4.59 (1.69)*	3.91(1.66)	3.89(1.76)	*3.90(1.70)*	*4.32(1.63)*
% laparoscopic surgeries[2]	31.6 %	30.7 %	*31.1 %*	51.2 %	53.2 %	*52.5 %*	56.5 %	59.3%	*58.0 %*	*45.3 %*

[1] Based on 367 surgeries; for 4 surgeries, the primary surgeon did not provide a ***difficulty assessment***. No significant differences with regard to difficulty of procedure during baseline and after the introduction of the intervention;

[2] Based on 371 surgeries. No significant differences with regard to the percentage of laparoscopic procedures in any of the hospitals during baseline and after the introduction of the intervention

Changes in Situation awareness between baseline and StOP?-briefing

Table 3 shows the results of ANCOVAs for residents, scrub nurses, anesthesia care providers and circulators. As shown in Table 3a, the two professions that are working directly at the operating table (residents and scrub nurses) did not show a significant change in situation awareness during the intervention period as compared to the baseline. Professions not directly at the table (anesthesia care providers and circulators) showed significantly higher situation awareness during the intervention period.

As shown in Table 3b, situation awareness was similar *across hospitals* for all professional groups except for circulators. Post-hoc tests showed that situation awareness was significantly lower overall for circulators in hospital 2 than in hospital 1 (P=0.010), or in hospital 3 (P=0.001). As indicated by the significant hospital * intervention effect for residents, residents' development of situation awareness differed between hospitals.

Operative access did not influence situation awareness for residents, scrub nurses or circulators, but for anesthesia personnel. They reported higher situation awareness for open surgeries (M=5.67, SD = 1.15) than for laparoscopic procedures (M=5.09, SD = 1.36) (t=2.145, P=0,033).

Additional analyses revealed that surgeries that were more difficult for primary surgeons were related to lower situational awareness for residents (r=-.18, P=0.002), scrub nurses (r=-.20, P<0.001), and circulators (r=-0.244, P=<0.001), but not for anesthesia care providers (r=-.06, P=0.227).

Table 3: Analyses of Covariance for each of the four occupational groups: Situation awareness

a) Influence of the StOP?-intervention

	Unadjusted	
	Baseline M (SD)	Intervention M (SD)
Residents (n=293)	6.32(0.89)	6.34 (1.03)
Scrub nurses (n=365)	5.96 (1.04)	6.10 (1.04)
Anesthesia care providers(n=364)	4.83(1.29)	5.55 (1.16)
Circulators (n=364)	5.26(1.27)	5.78(1.20)

	Adjusted						
	Baseline		Intervention				
	M	95%CI	M	95% CI	F (df=1)	P	Cov.
Residents (n=293)	6.34	6.17-6.50	6.33	6.18-6.48	0.001	0.976	a,b
Scrub nurses (n=365)	5.95	5.78-6.11	6.10	5.96-6.25	2.005	0.158	b
Anesthesia care providers(n=364)	4.83	4.64-5.03	5.54	5.37-5.71	29.22	**<0.001**	a
Circulators (n=364)	5.23	5.04-5.42	5.80	5.63-5.93	20.18	**<0.001**	b

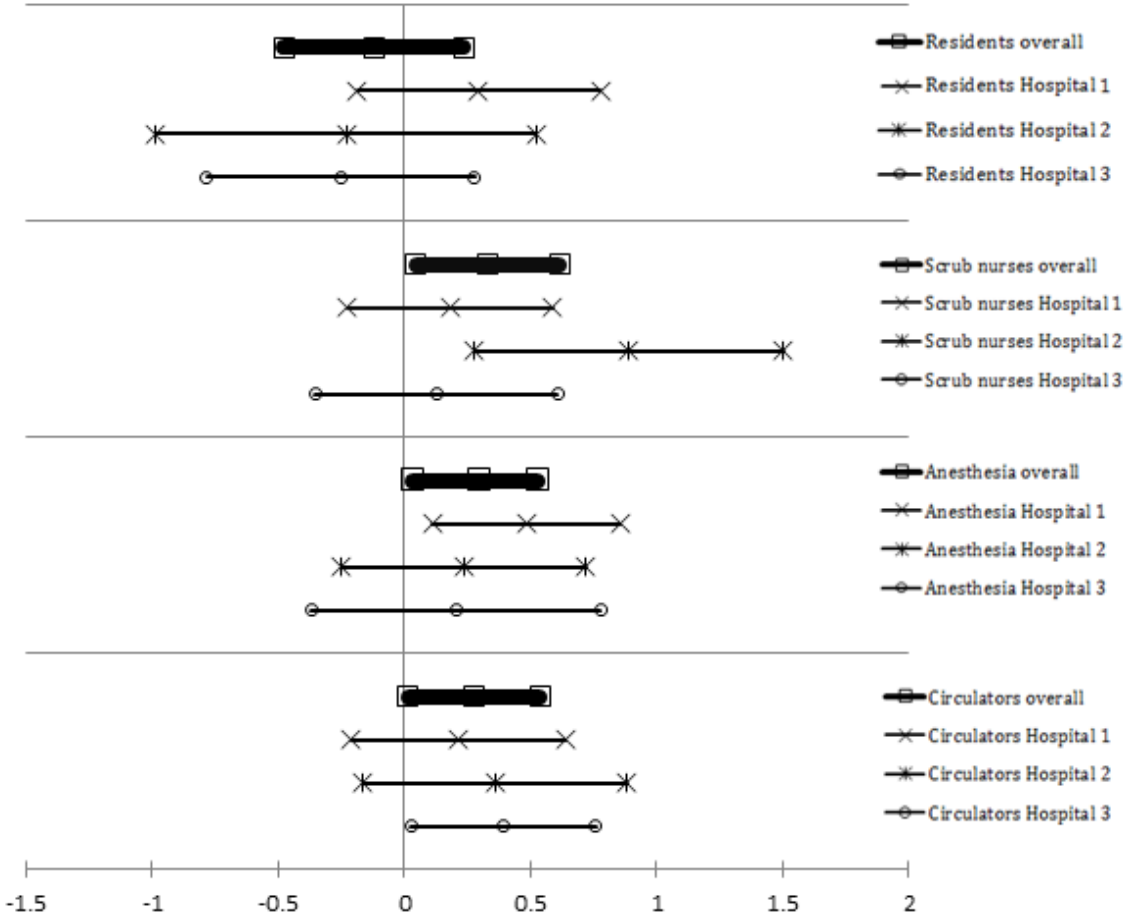
Notes: adjusted for difficulty level reported by primary surgeon and for operative approach
Cov: Covariate is significant for [a] operative access [b] Difficulty

b) Statistical parameters for differences between hospitals and for covariates

	Overall effect		Differences between **Hospitals**	
	F, df=7	P	F, df = 2	P
Residents	3.204	0.003	2.490	0.085
Scrub nurses	2.830	0.007	0.927	0.396
Anesthesia care providers	5.987	<0.001	.224	0.800
Circulators	8.378	<0.001	**7.796**	**<0.001**

	Covariate **operative access**		Covariate **Difficulty** rating		stop*hospital **interaction**	
	F, df = 1	P	F, df = 1	P	F,df=2	P
Residents	0.519	0.942	7.068	**0.008**	3.958	**0.020**
Scrub nurses	1.685	0.195	8.570	**0.004**	0.392	0.676
Anesthesia care providers	6.565	**0.011**	3.682	0.056	0.945	0.389
Circulators	0.971	0.325	14.357	**<0.001**	0.050	0.951

Figure 1: Forest-Plot: Effects of the StOP?-Intervention on situation awareness of residents, scrub nurses, anesthesia care providers and circulators overall and across hospitals.



Lines are mean differences before – after the intervention +/- 95% Confidence intervals (CI). Effects are significant if the CI does not include 0. Positive values indicate that the StOP?-briefing is related to enhanced situation awareness, negative values indicate that the StOP?-briefing is related to diminished situation awareness.

Secondary endpoint: Ease of speaking up.

As shown in Table 4a, ease of speaking up was generally high (5.7 to 6.2 on a 7- point scale). As compared to the baseline, scrub nurses, anesthesia care providers and circulator's ease of speaking up significantly increased during the intervention. The ease of speaking up for resident was not changed.

Post-hoc comparisons across hospitals revealed significantly lower ease of speaking up for residents in hospital 2 than hospital 1 (P=0.009), and in hospital 2 than in hospital 3 (P=0.002); significantly lower ease of speaking up for scrub nurses in hospital 2 than in hospital 1 (P=0.029), and lower scores (albeit not significantly) in hospital 2 than in hospital 3 (P=0.053). Circulators in hospital 3 reported higher ease of speaking up than in hospital 1 (P=0.031) or in hospital 2 (P<0.001).

Additional analyses revealed that in surgeries that were more difficult for the primary surgeon, ease of speaking up was lower for scrub nurses (r=-.13, P=0.012) and circulators (r=-.20, P<0.001). Difficulty was not related to ease of speaking up for residents (r=-0.018, P=.757) or anesthesia care providers (r=-.095, P=0.362).

Table 4: Analyses of Covariance for each of the four occupational groups: Ease of speaking up

a) influence of the StOP?-intervention

	Unadjusted	
	Baseline M (SD)	Intervention M (SD)
Residents (n=291)	6.12 (1.39)	6.03 (1.65)
Scrub nurses (n=364)	5.93(1.53)	6.26(1.24)
Anesthesia care providers(n=364)	5.76 (1.47)	6.08 (1.10)
Circulators (n=362)	5.81 (1.33)	6.01 (1.23)

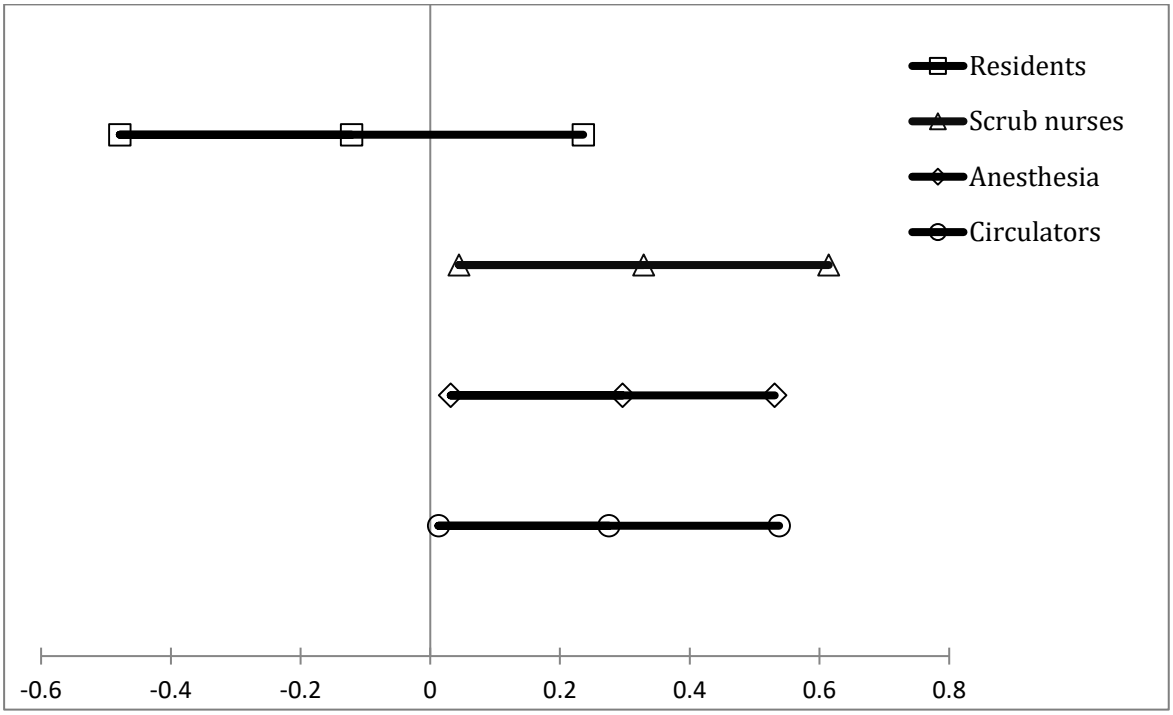
	Adjusted						
		Baseline	Intervention				
	M	95%CI	M	95% CI	F(df=1)	P	Cov.
Residents (n=291)	6.129	5.87-6.39	6.083	5.84-6.32	0.065	0.798	
Scrub nurses (n=364)	5.864	5.65-6.08	6.261	6.07-6.45	**7.372**	**0.007**	[a]
Anesthesia care providers(n=364)	5.743	5.54-5.95	6.064	5.89-6.42	**5.495**	**0.020**	
Circulators (n=362)	5.822	5.63-6.02	6.116	5.94-6.29	**4.878**	**0.028**	[a]

Notes: adjusted = for difficulty level reported by primary surgeon
Cov: Covariate: [a] significant for Difficulty

b) Statistical parameters for differences between hospitals and for covariates

	Overall effect		Differences between **Hospitals**		Covariate **Difficulty** rating		stop*hospital **interaction**	
	F, df = 6	P	F, df = 2	P	F, df = 1	P	F, df = 2	P
Residents	2.818	0.011	7.00	**0.001**	0.147	**0.702**	0.975	0.378
Scrub nurses	3.86	0.001	4.06	**0.018**	4.67	**0.031**	2.591	0.076
Anesthesia care providers	2.42	0.026	2.201	0.112	3.534	0.061	0.425	0.654
Circulators	6.049	<0.001	7.616	**0.001**	10.936	**0.001**	0.125	0.882

Figure 2: Forest-plot for effects of the StOP?-briefing on ease to speak up of residents, scrub nurses, anesthesiology care providers and circulators.



Lines are mean differences before – after the intervention, +/- 95% CI. Effects are significant if the CI does not include 0. Positive values indicate that the StOP?-briefing is related to higher ease to speak up, negative values indicate that the StOP?-briefing is related to lower ease of speak up.

Discussion

The StOP?-briefing - a short and relatively simple intervention that encourages primary surgeons to provide task-relevant information to the surgical team before critical phases of the surgeries - enhanced situation awareness of members of outer circle of the surgical team namely anaesthesia and circulating nurses. Thus, the intervention effectively addresses one of the most important complaints of operating room team members [32]. Scrub nurses hand instruments to the surgeon throughout the procedure, and thus get first-hand information about the progress; a similar argument can be made for residents. These two groups have better access to visual information, and they are more likely to understand information exchanged throughout the surgery. Team members in the outer circle not only have less visual information; in addition, they may not overhear the information exchange at the table, which may be communicated in a low voice and directed specifically at team members at the table. These results underscore the importance of updates by the surgeons that are targeted at all team members and are communicated in a clear and well audible way beyond the inner circle. The importance of such "talking to the room" for keeping team members informed has already been shown in crisis situations [42, 43] and has been found important for sense-making in ambiguous situations [44].

The StOP?-briefing enhanced not only situation awareness but also the ease of speaking up for scrub nurses, anesthesia care providers, and circulators. Two aspects of the StOP?-briefing may be responsible for this effect. First, the StOP?-briefing ends with an explicit encouragement by the primary surgeon to voice questions or concerns, which may serve as a reminder for team members that speaking up is a behavior supported by the surgeon. Second, all team members interrupt their tasks to participate in the StOP?-briefing. Similarly to the introduction of the WHO checklist procedure [45], this interruption may indicate that everyone is ready to focus on exchanging information; this may have a positive effect on team climate, which has been shown to facilitate speaking up [46] [35]. It is well known

that hospitals and departments have different cultures and climates[47], this may explain differences between hospitals.

In this study, the effects of the StOP?-briefing were controlled for operative access and for difficulty. It is interesting to note that situation awareness was not higher for laparoscopic surgeries, despite the fact that, normally, several screens are available in an OR that allow team members to follow the procedure. To the contrary, anesthesia care providers reported lower situation awareness in laparoscopic than in open procedures. This may be explained by the fact that anesthesia care providers do not always have ready access to a screen broadcasting the surgery, but it could also mean that in absence of verbal cues the information on the monitor may not be sufficient and self-explanatory information.

Difficult surgeries lowered situation awareness for residents, scrub nurses and circulators, and - albeit just not reaching conventional significance levels - also for anesthesia care providers. This is an important finding, because team situation awareness is particularly important for performance in difficult and emergency situations [2]. On the one hand, difficult surgeries may also be more difficult to follow, but on the other hand, it may well be that, during difficult surgeries, surgeons are more concentrated on the operative field and less focused on their role as team leader. Previous research has shown that in stressful situations, people tend to concentrate more on their individual tasks and to lose the team perspective [48]. The StOP?-briefing may counteract this tendency.

Difficult surgeries are also related to lower ease of speaking up, particularly for scrub nurses and circulators. Speaking up is most important in difficult situations [49], and again, reminding the team to voice their concerns may be particularly useful during such situations.

The *limitations* of this study are typical for many intervention studies: We could not blind the participants, nor the observers, about the intervention. Collecting data after each surgery constitutes a limitation to sample size. We also did not have the possibility to include control-groups who did not receive the intervention, so history effects cannot be excluded.

However, the pre- and post- intervention periods were staggered in time across hospitals, providing a partial control for overarching history effects. During the observation period, none of the hospitals underwent a major organizational change.

The *strength* of the study is its multisite nature; it included three different hospitals, and data were collected from all team members separately and directly after surgeries, thus limiting the bias of general self-reports [50].

We conclude that the StOP?-briefing, a short, task-adapted intervention that can be implemented rapidly and easily, has clear positive effects in the expected direction: It enhances team situation awareness and ease of speaking up, particularly for team members not directly working at the table and for team-members lower in the hierarchy. In addition to preoperative and postoperative briefings recommended for surgeries, short structured information updates provided by the responsible surgeons should be implemented.

We believe that there are some important elements that contributed to the overall effects shown in this paper. First, the intervention is rather simple and does not require complicated procedures; second, it is short, typically ranging from about 45 seconds to 1 ½ minutes; third, the timing of the StOP?-briefing was optimally adjusted to the surgeons' workflow, based on their assessment of a "natural" break between two action cycles. Finally, the intervention included an extended preparation period; this included interviews with the surgeons to determine optimal points of carrying out the StOP?-briefing, based on a task analysis of their procedures; it also included the possibility for each professional group to voice concerns and request adaptations. We strongly recommend that these elements should be included in any attempt to introduce a procedure like the StOP?-briefing.

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4. Discussion

Each paper and manuscript already has its own detailed discussion section, therefore in this chapter, I do not focus on details but rather on the main results, similarities, and what this means for the overall topic.

To match the general structure of this thesis, the discussion chapter is split into a stress and a briefing discussion part. Included in each section are also limitations and strengths, directions for future research, and implications for the practice.

Although this thesis consists of two separate topics, there are overlapping and common aspects in the studies from both topics. Therefore, I add a third part where I discuss those aspects.

4.1 Discussion Stress part

The three papers in the first part of this thesis looked at the issue of stress and stressors in and outside the OR in detail, mainly for surgeons.

The goal of the workday paper was to analyse the workday of hospital surgeons by letting them fill in daily questionnaires, asking about their overall work condition and daily work tasks. About one fifth of their time was spent with surgery related tasks, another fifth with patient related tasks, almost a fifth with documentation and administration, and about 10% with meetings and communication about patients. They rated surgery as most and administration as least attractive task. The more administration they had to do, the lower was the perceived legitimacy of it, which correlated with job satisfaction.

The workday paper showed what tasks the surgeons face in their workday and how they perceive those tasks. Their core task – doing surgery – was liked most by the surgeons. Since this is the defining task of what makes a surgeon, they most likely chose to be a surgeon because they like doing surgery (Seelandt, Kaderli, et al., 2014). On the contrary, they liked doing administration the least. Administration is an often cited reason for dissatisfaction and stress (Meyera, Rohnerb, Golderc, & Longchampd, 2016). Administration is not directly patient related and uses time they would rather spend on core medical tasks. The more time spent on administration, the more is it perceived as illegitimate. It seems that a small amount of administration is perceived as necessary, but the more time it detract from core tasks, the more it is disliked. In addition, task characteristics themselves could contribute to the likeability. Surgery has the goal to help patients, improve or even save lives. After successful surgery, the surgeon can see the improvement in the patients' health at the check-up.

While administration, although necessary to a certain degree, does not have such directly perceivable value.

Although surgeons like doing surgery the most from their tasks, doing surgery itself and its environment is prone to be stressful. In the OR, surgeons are faced with a list of potential stressors (Arora et al., 2009). Studies looking at the existence and distraction potential of those stressors are numerous (Anton et al., 2015; Arora, Hull, et al., 2010; Wong et al., 2010), but how and when exactly the stressors disturb the surgeons during the surgery is often neglected. The noise paper and the communication paper therefore looked in detail at two stressors in the OR itself.

In the noise paper, noise exposure in the OR was measured and related to self-reported distraction levels. Results showed that noise pollution led to particularly high distraction in high mental workload phases. Since the phases of high concentration are not the same for all team members, different team members are distracted more in different phases. For second surgeons this was the main phase and for anaesthetists the closing phase. The paper confirms previous research by showing the loudness and the distracting potential of noise in the OR (Healey et al., 2007; Katz, 2015; Szalma & Hancock, 2011). It adds to this by looking at the distracting potential of noise during different surgery phases and for different team members. It suggests that noise is especially distracting in phases where team members have a high workload and therefore high concentration demands.

In the communication paper, the content of case-irrelevant communication (CIC) in the OR was evaluated. There was less case-irrelevant communication during surgeries that were rated higher in difficulty by the surgeons. Work-related CIC was more frequent than social CIC. While frequency of work related CIC was constant across surgery phases, social CIC increased across phases. Social CIC increased during the closing phase, possibly because the atmosphere is more relaxed after the most difficult phase and concentration demands are lower. This shows that surgical teams adapt their communication to the demands of the procedure. The communication paper adds to previous research by exploring the specific content of CIC and exploring the regulation of it. As CIC is often researched as distractor (Healey et al., 2007; Healey et al., 2006), the content is often neglected.

Overall, the papers provide a surgeons workday overview and deeper insights into the mechanisms of two stressors. There are also potential connections between the study findings. For example, in the workday paper, surgeons claimed to dislike doing administration and that they perceive they have to do too much of it. Meanwhile in the communication paper, the work-related CIC during surgery contained communication about administrative and organizational issues. If the amount of overall administrative work would be reduced, the surgeons would ideally have enough time to handle most of the administration outside the OR. Therefore, less discussion about it during surgery would be necessary, interfering less with highly sensitive work. Another example would be that more CIC was reported during the closing phase of the surgery, especially social CIC, which is presumably

causing additional noise in the room. The noise paper suggests that the anaesthetists need more silence during this closing phase. The communication paper suggests that surgeons are able to control their case-irrelevant communication, when they need to concentrate. Making the surgeons aware of the concentration demands of the anaesthetists during the closing phase, could make them help reducing the noise for the anaesthetists, by reducing case-irrelevant communication. Therefore, it is important to look at possible connections between different stressors and not only at the stressors itself.

Implications for the practice

These studies showed that workload and other stressors are still a concern for surgeons. There are a high diversity of stressors inside and outside of the OR in a surgeon's workday; therefore it is impossible to get rid of, or control every single one of them. However, by figuring out what stressors there are and analysing how they cause stress it is possible to develop means to lessen the impact of some stressors. In addition, surgeons can better develop coping strategies for specific stressors, if they are aware of stressors. Other researchers have already suggested stress management training for surgeons to help develop coping skills (Anton et al., 2015; Klein et al., 2011). Junior surgeons in training could particularly benefit from it, since they will not already developed specific coping strategies of their own.

As for noise as a stressor, equipment which is more quiet to use could be developed. Alternatively, there could be training as to how to handle certain instruments less noisily (e.g. the way circulators put away used instruments). This could also have impact on the CIC; one study showed that noise peaks influence communication in the OR. More noise led to less case-relevant and more case-irrelevant communication (Keller et al., 2016).

In the communication paper, surgeons did control their communication according to surgery difficulty. This suggests surgeons will control a stressor when possible. Therefore, means to make certain stressors more controllable should be implemented.

Limitations and future research

One limitation of the studies is that none of them looked at patient outcomes or other performance measures. Although the possible influence of stressors on surgeons' well-being is important, patient outcomes should not be neglected. Getting patient data and successfully associating them to specific stressors is not an easy task; nevertheless, future studies should try to include measurements of patient outcomes.

The focus of the studies was on the surgeons. Only the noise paper assessed effects on other team members in the OR. Workday analyses may also be beneficial for anaesthetists and nurses to find possible causes of stress, since those jobs are also known for being stressful (Chen et al., 2014;

Dagget, Molla, & Belachew, 2016; Megan Conner CRNA, 2015; Padilha et al., 2017). Not only assessing stressors for other team members separately, but also comparing those assessments could be beneficial. Tasks done by those with different professions could be better coordinated with each other. The possibility to compare different assessments could help to improve the quality of the work environment.

Two of the papers each looked in detail at one intraoperative stressor. One limitation is that only two stressors were analysed, since there are plenty of other intraoperative stressors. Considering the effort it takes to examine one single stressor in detail, it would be time consuming to look at more stressors. Nevertheless, it would certainly be an option to take a closer look to further stressors in future studies.

The studies assessed what may stress surgeons. This is a necessary first step for identifying sources of stress. A further step for future studies would consequently be to study what possibilities and methods there actually are to improve the situation for surgeons.

Method-wise, all studies used self-reports at some point. These are known to have certain limitations, such as response bias and memory effects (Paulhus & Vazire, 2007; Razavi, 2001). One means of avoiding the limitations of self-report was to let the participants fill in the questionnaire within a short amount of time after the surgeries, thus reducing memory effects. In the workday paper, a daily approach was used and the time spent on different tasks was comparable with another study which used observational data (Mache et al., 2010). The other papers used additional measurements to combine with self-report to reduce common method bias. The noise paper used a decibel meter and the communication paper used a validated observation system (Seelandt, Tschan, et al., 2014).

4.2 Discussion StOP? part

In the centre of the second part of this thesis was the introduction of an intraoperative briefing, the StOP? protocol. The manuscripts in this part therefore are thematically based around the StOP?, its effects, and what should be considered when implementing an additional briefing.

The StOP? introduction paper describes the conceptualization and implementation of the StOP? protocol. Why it was developed in the way it was, what problems had to be taken into account and what the goals of the StOP? protocols were. Interviews with surgeons showed that surgeons preferred certain points during the surgery, where they considered StOP?'s useful and feasibly. The interviews also showed that those points differ mostly between surgeries, but also between surgeons and local hospital practice. This goes conform with previous research, which suggested approaches to foster teamwork during surgery to be adapted to the work setting, specificities of the system and

specific task aspects (Catchpole et al., 2018; McCulloch et al., 2017). The StOP? adds to previous research by being an intervention to foster communication in the OR with a intraoperative briefing, instead like most other briefing interventions which concentrate on prebriefings or debriefings.

When implementing a new briefing, like the StOP?, there are numerous influences on compliance. To make the introduction a success high compliance is necessary and therefore it is important to take account for those influences. The compliance paper analysed how high the compliance was with the StOP? and evaluated context and task-related factors influencing this compliance. Depending on the compliance assessment and hospital, compliance rates were between 62%-91%, which are comparable to rates in studies on introducing the WHO checklist (Gołębiowska, Gołębiowska, Chudzik, Jasiński, & Dubelt, 2018). Results also show that compliance depends on the hospital, urgency (elective vs. emergency), surgical access (minimal invasive vs. open), and duration of surgery. This conforms to some of the literature about the compliance of preoperative safety checklists and with the known circumstance that hospitals have different cultures (Sexton et al., 2006). The compliance paper showed that the StOP? reached a good level of compliance and that it is essential to adapt an intervention to the respective circumstances.

Perceived redundancy and checklist fatigue were a concern when introducing the StOP?. The StOP? protocol could have negative effects on the already established team timeout. The timeout paper analysed the effect of the newly introduced StOP? protocol on the quality of the already established preoperative timeout. After the StOP? introduction, the timeouts had a higher completing rate, were rated as less noisy, and rated higher in terms of engagement, pace, and social atmosphere. The positive influences of the StOP? on the timeout, could be due momentary effects; anticipating the StOP? enhances overall attention and therefore the timeout gets more attention as well. Alternatively, it could be due more general effects; the training for the StOP? served as reminder of the importance of information exchange in the OR, therefore enhancing overall information exchange. This conforms to earlier studies, where cooperative behaviour was influenced beyond specifically targeted interventions (Okhuysen & Eisenhardt, 2002).

The StOP? team paper investigated the effect of the StOP? protocol on the situation awareness and ability of speaking up of the surgical team members. Situation awareness during the intervention was enhanced for anaesthesia care providers and circulators, team members not directly working at the operation table. Ease of speaking up was enhanced for scrub nurses, anaesthesia care providers, and circulators. Since visual and verbal information may be blocked, following the process of the operation may be hindered for team members not directly working on the operation. The StOP? fosters information sharing, so they may get information, when they usually would not. The StOP? explicitly encourages speaking up, by giving an opportunity to do so, which the team members actually seem to seize.

Overall the papers on the StOP? show the effects and mechanisms of a task-adapted, intraoperative briefing in the OR. Implementing and carrying out an intraoperative briefing is not only feasible, but has the intended benefits for the members of the surgical team - provided the development, adaptation and introduction is carefully arranged and conducted.

Implications for the practice

The first analyses have shown, that the StOP? intervention has positive effects on the team. It is therefore recommended to introduce the StOP? protocol or something similar which helps the responsible surgeon provide short structured information updates for the team during surgery. What contributed to this was that the StOP? is rather simple, short (about one minute) and adjusted to the surgeon's workflow (task-based). If a hospital decides to implement such an intraoperative briefing, it is highly recommended to have an extended preparation period, which includes determining optimal points of carrying out the briefing, and giving the opportunity to each professional group to request adaptations and voice concerns.

In our study, the timeout profited by the introduction of the additional StOP? protocol. This means, additional briefings can help to improve the quality of already established briefings. However, it should also be considered that other hospitals might already have other numerous checklists and briefings established at other moments before and after the surgery. This could in certain circumstances lead to perceived redundancy and checklist fatigue. Therefore in specific cases, it would be best to take account for other possible checklists already in use and then search for redundancies and possibly eliminate them.

Limitations and future research

A strength of the StOP? study was its multicentre design. With the data collection in more than just one hospital, possible hospital effects could be studied and controlled. The multicentre design also contributed to a rather high study sample.

Although the StOP? study took place in multiple hospitals, it predominantly took place in hospital departments of general and visceral surgery. For the sake of generalizability, the StOP? protocol should be implemented in other surgical disciplines. An intratask briefing like the StOP?, with the necessary adaptions, could even be implemented outside surgery in other health disciplines where short briefings during a longer task could be beneficial.

Definitely, patient outcomes possibly influenced by the StOP? introduction should also be analysed. Within the StOP? project, patient data was collected, but have not yet been analysed. There will be papers in the future analysing this data.

The StOP? was introduced in real ORs and not in simulations. This is good for external validity, but also has the disadvantage that it was not possible to entirely blind the people involved in the study. Participants may not have known all specific research questions, but naturally, they were aware of the intervention itself. Since it was not possible to have control groups, group conditions could not be manipulated and history effects cannot be excluded.

4.3 Combined Discussion

Multiple connections can be drawn between the studies from the first and the second part of this thesis.

Among other things, team communication can be a coping mechanism from surgeons to reduce intraoperative stress levels (Anton et al., 2015). Since the StOP? fosters team communication, the StOP? could be used as a form of coping. In addition, the StOP? is also an opportunity to help relax. The surgeon can use it to take a step back from the work, can address the situation while updating the team, and maybe even get input from the team that could help with their work. Nevertheless, the StOP? can be a little pause to breath, which alone can reduce mental stress (Engelmann et al., 2011).

The StOP? could also help to reduce noise in the OR. Behaviour is a source of noise and the StOP? is an opportunity to calm the OR. Everyone has to pause their (possible noisy) work to listen to the StOP?, which itself already calms the room. In addition, if it is too noisy for the surgeon or other team members, they can address this during the StOP?. For example, when a StOP? is made before closure, the last phase in the surgery which is the most noisy, the anaesthetist could ask other team members to be quite, so they are less distracted by noise.

The StOP? can also help to get case-relevant communication back on track, when concentration is fading. Distractions diminish case-relevant communication during surgeries (Keller et al., 2016) and the StOP? fosters case-relevant communication.

Through the advantages of the StOP? in terms of communication it could have similar benefits such as the timeout. One of those is the possibility to save time through smoother cooperation (Anderson et al., 2017). If the StOP? really does contribute to smoother cooperation and therefore saving time, the surgeons and other team members may have more time during the day for their other work tasks, therefore reducing time pressure of the overall work.

Limitations and future research

Data for all studies in this thesis were collected in real-life settings with real surgical professionals. Although this has the weakness that no control groups could be established and no experimental manipulation was possible, real-life settings are important and have the advantage of good external validity. Compared to simulations, studies made within the surgical environment capture the full range of challenges faced in real ORs.

Most studies sourced their data from more than one hospital, but all were conducted solely in Switzerland. Although findings from similar research outside Switzerland conforms to our findings, external validity would certainly benefit if this research would be conducted in other countries as well.

Furthermore, the observations and self-reports, which some studies rely on, were all made during elective surgeries. Data collection should be expanded to emergency procedures, since teamwork and communication during emergencies are even more challenging, due the patients being in an immediately life-threatening position, possibly making the surgery more hectic and stressful. Data from emergency procedures would also be interesting in terms of case-irrelevant communication, noise and measurements related to the StOP?. Additionally, as the StOP? compliance paper showed, compliance in emergency surgeries is lower, so it would probably benefit the compliance when observers are present during emergency procedures.

5. Conclusion

This thesis contains two topics that are linked to the work of surgeons. First, this thesis identified possible sources of stress for hospital surgeons by getting a detailed picture of their whole workday and analysed how and under what conditions two of known stressors are most stressful. Second, this thesis described the implementation of the StOP? protocol, monitored if the implementation was successful, if there were influences on the team timeout, and conducted analyses related to its intended goals concerning teamwork and communication. Identifying the sources of stress is the first step to develop the means to lower said stress by diminishing or counteracting the stress sources. As for counteracting, the StOP? has shown to have positive effects in the expected direction and could even be used to reduce influences of certain stressors. Further studies are necessary to fully grasp all the effects of the StOP? and to find further possibilities to diminish the influences of stressors. This thesis therefore contributes to a detailed understanding of stress sources for surgeons and provides a tool to facilitate good teamwork in the operating room, with the potential to diminish the stress of surgeons during surgery. These results can therefore serve as a basis for improving the work of surgeons by making their work less stressful.

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Appendixes

Kündig, P., Tschan, F., Semmer, N. K., Morgenthaler, C., Zimmermann, J., **Holzer**, E., ... & Marsch, S. (2019). More than experience: a post-task reflection intervention among team members enhances performance in student teams confronted with a simulated resuscitation task—a prospective randomised trial. *BMJ Simulation and Technology Enhanced Learning*, *bmjstel-2018.*

More than experience: A post-task-reflection intervention among team-members enhances performance in student teams confronted with a simulated resuscitation task - a prospective randomized trial.

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Word count text: 3336
Number of figures and tables: 2 Tables, 2 Figures
Conflict of interest declarations: None of the authors declares a conflict of interest

Author Notes and Acknowledgements

We thank Mina Dimitrova, Nadja Jenni, and Patrick M. Huber for their help in transcribing and coding data; Mark Breuer and Sabine Schweizer for their help in data collection.

Funding statement:

This work was supported by the Swiss National Science Foundation, grant # 149734

Contributor statement:

All authors approved the final version of the MS.

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ABSTRACT

Background: Teams that regularly step back from action and deliberately reflect on their performance and strategies show higher performance. Ad-hoc emergency teams with changing team composition cannot develop such habits but may engage in short post-action reflection to discuss shortcomings of past performance and potential adaptations of their strategies for future similar tasks. This study aimed to test the effect of a short post-action self-led reflective team briefing on resuscitation performance in a simulator setting in terms of three performance parameters: hands-on time, coordination between chest compression and ventilation, and defibrillation.

Methods: We performed a randomized controlled trial including 56 ad-hoc formed teams of three fourth-year medical students each. All groups performed a resuscitation task, followed by a self-guided reflective briefing, based on a general instruction (n=28 teams), or an unrelated discussion session (control condition; n=29), followed by a second resuscitation task in the same team composition.

Results: Adjusted for performance in the first task, teams in the reflection condition showed higher performance gain the second resuscitation than teams in the control condition (6.21 percentage points (95% CI = 1.31 – 11.10, $p<0.001$)) for basic hands-on performance; 15.0 percentage points (95% CI = 2-28, $p < 0.001$) for coordinative performance, but non-significantly lower performance for defibrillation (-9%, 95% CI = -27-9%, $p=0.312$).

Conclusion: Even very short self-led post-action reflective briefings enhance basic resuscitation performance in ad-hoc groups, but may not influence more complex aspects of the task. We recommend including short self-led team debriefings as part of simulator training.

KEYWORDS:

Cardiopulmonary resuscitation 89

Team learning

Reflective briefing

Ad-hoc teams

WHAT THIS PAPER ADDS

What is already known on this subject:

Reflective briefings such as huddles or post-action briefings are advocated widely as a mean to learn and to prepare for coordinated teamwork; previous research suggests that they should be led by an expert. There is, however, little empirical evidence on effects on performance of very short briefings if expert-guidance is not available. Furthermore, boundary conditions such as task complexity require more research.

What this study adds:

This study shows that medical teams that engage in a very short self-led post-action reflective briefing improve their task performance on a similar task. However, the briefing is more effective for basic than for aspects of the task that can be considered more complex. We recommend such briefings as a simple and rapid mean of team learning and also suggest including them into simulation training, but to keep in mind that improving more complex aspect of a task may require expert guidance.

INTRODUCTION

Many medical emergencies are dealt with by very closely cooperating teams. Performance of such teams depends, among other aspects, on the quality of team collaboration.[1] It is thus imperative to find ways of improving team collaboration in medical emergencies. Team training is an effective means to influence teamwork; it improves outcomes such as medical performance, patient outcomes, and patient safety.[2 3]

An important way to support team learning involves team members stepping back from the action, engaging in deliberate reflection about their past performance, their task- and collaboration-related strategies, and discussing strategies for future tasks.[4 5] Team training providing an opportunity to engage in such reflective phases has been found to be particularly effective.[6 7]

However, team learning does not only take place during formal training. Previous studies found that teams that develop habitual routines to regularly engage in reflection show higher performance and more innovation. [8 5 7] As developing routines presupposes membership continuity over time, these findings mostly apply to teams with a history of collaboration;[9] such temporal and compositional team stability is rare in medical settings. [10 11] Particularly in emergency situations, teams often are formed ad hoc and collaborate for only a short period of time and then disband, [12] making it unlikely to develop routines of reflection. Nevertheless, ad-hoc teams can engage in short reflection before, during or after collaboration to enhance performance. Studies in other fields,[13] but also in medicine,[14-18] showed mostly positive effects of short reflection phases for ad-hoc teams.

In everyday practice, medical teams are encouraged to engage in reflective discussions – often called briefings. [19] A recent overview an reflective briefings in medicine [20] distinguishes briefings by their temporal position with regard to the task. In *pre-action* briefings, teams reflect and discuss before collaboration and reflect about the upcoming tasks and the optimal preparation of the team (e.g. team timeouts in surgery;[21] huddles before

starting a complex task [22]). *In-action* reflection takes place during an ongoing task, when the team halts all but life-saving activities and engages in a briefing with the goal of optimizing present care or adaptation to changing task conditions. In *post-action* briefings, teams reflect after the task (e.g. mortality and morbidity conferences[23]), and analyze past performance with a focus on future, similar tasks.

For emergency situations, which are the focus of the current study, pre-action briefings are possible only under very specific circumstances (e.g. while waiting for a patient to arrive[24]). However, most emergencies require immediate action, and even short delays may harm the patient. [25] In-action briefings may also be very difficult to carry out, particularly if the patient needs constant attention and team members cannot interrupt the action to focus their attention on a briefing. Thus, post-action briefings seem most promising for team learning of ad-hoc emergency teams. Previous research shows that reflective post-action briefings have greater impact if they are led by an expert [6 26] or by a team leader,[27] and they yield better results if performance feedback is provided.[17] As objective feedback or an expert adviser are often not available after an emergency, the question arises if post-action briefings relying on team self-guidance can be valuable. There is little empirical evidence that self-led post action briefings improve performance.

The main goal of the current study is thus to test the effects on performance of a short self-led post-action briefing intervention in ad-hoc teams of first responders performing a cardiopulmonary resuscitation in a simulator setting.

Primary endpoint is resuscitation performance when treating a patient suffering a cardiac arrest by teams that engaged in a short post-action briefing after a previous, similar task, as compared to teams that did not. As performance is multi-dimensional,[28-31] it is important to distinguish several components of performance. Based on the resuscitation algorithm,[32] we assessed basic performance (measured as hands-on or flow time);

coordinative performance (coordination between chest compression and ventilation) and defibrillation performance.

METHODS

Participants and Setting

This prospective observational study was conducted in the simulator room of an Intensive Care Unit (ICU) at a midsize European University Hospital. The study was approved by the local ethics committee; all participants provided signed informed consent. Participants were fourth-year medical students, which are a good representation of medical professionals with a theoretical knowledge base (they all had theoretical knowledge of symptoms of cardiac arrests and cardiopulmonary resuscitation, CPR) but limited hands-on practice and limited collaboration practice for medical tasks. This work was supported by the Swiss National Science Foundation, grant # 149734.

Participants were assigned to teams of three according to their scheduling preferences. Because all medical students were part of the same cohort, members working as a team may have known each other; but they did not have common working experience. The students were blind to the goal of the study.

The patient simulator used consists of a high fidelity manikin that was controlled remotely by the operator (Meti®, Medical Educational Technologies, Inc.). It has realistic physiological features, including the ability to talk (through a connection to the control room). The simulator room was equipped as a standard ICU patient room, with one wall as a one-way mirror that allows the observation from the control room.

Study design

This is a prospective, randomized controlled trial. The teams were first confronted with a patient suffering a cardiac arrest (task1, see figure 1). After this, they were randomly assigned to either a discussion task unrelated to resuscitation (control group) or to a self-guided reflective post-action briefing. All teams then performed a second resuscitation task in the same team composition (task 2). We excluded one team from analysis because they misdiagnosed the patient's condition in the second task and were joined by a confederate to

successfully terminate the task. Of the 56 remaining groups, 29 were in the control condition and 27 in the briefing condition.

Scenarios and self-led briefing intervention

Upon arrival, the students were shown the simulator room and the manikin. They were then asked to wait in the hallway as a team. A confederate nurse stayed in the room throughout both scenarios, but intervened only when asked.

Task1, cardiac arrest: The confederate nurse met the group in the hallway and instructed them to intervene with an emergency in the simulator room. A manual defibrillator was available in the room. The nurse explained that the patient did not feel well after a diagnostic procedure and that he was asked to lie down. Upon entry of the group, the patient was lying on the bed and was unresponsive, not breathing and with no palpable pulse. A monitor displaying the patient's cardiac rhythm showed ventricular tachycardia. The team had to diagnose the cardiac arrest and initiate resuscitation. The patient did not regain spontaneous circulation regardless of the actions of the team. Three minutes into the resuscitation, the team was interrupted by a confederate.

Briefing intervention: After the interruption, the teams assigned to the self-led briefing condition were handed a sheet with instructions on how to reflect. The instructions were adapted from other studies [16 17 33 20] and contained a suggestion to discuss and look back at the situation just experienced, analyzing (a) what went well, (b) what did not go well and why, and (c) discussing strategies on how to proceed, should the team encounter a similar situation again. Teams did not have access to electronic or other sources of information during the briefing. After three minutes of discussion, the team was interrupted by a confederate and asked to proceed to the next patient.

Control group: The teams assigned to the control group where ask to huddle around an X-Ray display board displaying a thorax and were given basic patient information about another patient. The team was asked to diagnose the patient's condition (a pneumothorax) and

provide treatment recommendations. After three minutes of discussion, the team was interrupted by a confederate and asked to proceed to the next patient. The task of the control-group was chosen to be similar in all aspects (talking about a medical problem as a group) with the exception of the content of the discussion. Thus, it can be ruled out that effects of the intervention are actually due to the intervention groups simply spending more time together engaging in discussions and getting to know each other better – independent of the specific content of these discussions.

Task 2, cardiac arrest: After the discussion sessions, the teams were immediately introduced to the next patient. The confederate handed over patient information and told the team that the patient was not feeling well after an ambulatory stress electro cardiogram. The team was asked to interview the responsive patient with the aim of providing a recommendation on whether the request of the patient to leave the hospital could be granted. During the interview, the patient complained of pain in the legs (from cycling) and provided standard answers to medical and demographic questions. Two minutes into the interview, the patient said that he felt dizzy, then became unresponsive, closed his eyes, stopped breathing and had no palpable pulse. The monitor showed ventricular tachycardia, and the team had to recognize the situation as a cardiac arrest and start CPR.

Measures

Three performance measures were derived from the in-hospital resuscitation algorithm [32] and adapted to the simulation scenario:

Percent of *Hands-on time* (hands-on performance) measures basic CPR efficiency as percentage of time the team provided uninterrupted chest compressions, ventilation or defibrillation on the pulseless manikin. Five seconds before and after defibrillation were counted as hands-on time to account for the shift between chest compressions and defibrillation and to allow for controlling of defibrillation effects.

***Coordination* between chest compressions and ventilation** (coordination performance) was assessed by two independent observers based on video recordings, and consisted of two sub-scores. *Synchronization between chest compressions and ventilation* was rated on a four point scale (0=chest compressions and ventilation overlapping during the whole procedure; 1 = chest compressions and ventilation overlap more often than alternate 2 = mostly alternating, some overlap 3= chest compression and ventilations never overlap. *Correct application of the 30 (chest compressions) to 2 (ventilations) rule* was coded as 0 (if not observed) and 1 (observed). The two measures were combined with equal weights into one indicator and transformed so that optimal coordination performance yielded a score of 1.

Defibrillation performance was assessed by two independent observers, based on the recordings, and consisted of two sub-scores: *Compression/ventilation cycles* were coded as incorrect (0) or correct (1) depending on whether they conformed to the number of chest compressions/ventilation cycles between two defibrillations (five according to the resuscitation algorithm in 2010). *Minimizing the pause between CPR and defibrillation* was based on the time of interruption between CPR and defibrillation and coded as 0 (if more than 10 seconds), 1 (between 6 and 10 seconds), or 2 (between 0 and 5 seconds). [32] The two measures were combined into one indicator with equal weights and adjusted to measure defibrillation performance between 0 (minimal) and 1 (maximal performance). Defibrillation performance was assessed for task 2. For task 1, it was assessed whether (1) or not (0) the team attempted to defibrillate.

Objectives of the study

Primary goal was to assess the effect of the reflective briefing intervention on three aspects of resuscitation performance: hands-on time, coordination between chest compression and ventilation, and defibrillation performance.

Statistics

We used ANCOVA to assess differences in performance between conditions in the second task. To adjust for the effects of having practiced this task, we included the respective performance score of task 1 as covariate for hands-on and coordination performance. Because only half of the groups attempted defibrillation in task 1, we included defibrillation attempt, coded as yes (1) or no (0), as covariate when evaluating defibrillation performance in task 2.

Performance measured as percentages (hands-on performance) was arcsine transformed; statistical values are reported based on the transformed variables; but descriptive results as percentages and proportions. Analyses were performed with IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA). $P<0.05$ was considered statistically significant.

RESULTS:

Demographic characteristics and gender composition of the teams are displayed in TABLE 1. Six students did not provide data on age. The unbalanced gender team composition reflects the current gender distribution of medical students.

TABLE 1 Participant demographics and team gender composition

Participants (N=168 participants)			
Age	Mean (SD)	24.44	2.36
Females	n(%)	117	69.64%
Males	n(%)	51	30.36%
Year of study	Mean (SD)	4	0
Team composition (N=56 groups)			
all female	n(%)	17	30.36%
two females, one male	n(%)	28	50.00%
one female, two males	n(%)	10	17.86%
all male	n(%)	1	1.79%

TABLE 2 summarizes the results for all performance measures; FIGURE 2 illustrates the results.

Hands-on performance in the first task was a significant and independent predictor of hands-on performance in the second task. Teams in the briefing condition increased their performance by 16.8 percentage points between task 1 and task 2; teams in the control condition by 8.6. After adjusting for performance (experience) in the first task, hands-on performance was 6.21 percentage points larger for teams in the briefing condition as compared to teams in the control condition (TABLE 2).

Coordination performance in the first task was also a significant and independent predictor of coordination performance in the second task. Teams in the briefing condition increased their coordination performance significantly more than teams in the control condition: After adjusting for coordination performance in the first task, performance gain for

teams in the briefing condition was 0.15 points (or 15%) larger than for teams in the control condition (TABLE 2).

Teams in the briefing condition showed a slight, but non-significant, lower ***defibrillation performance*** in the second task than teams in the control condition (-0.09 points or -9%). Experience with defibrillation in the first task was not a significant predictor for defibrillation performance in the second task.

TABLE 2 Effect of the briefing intervention on Hands-on resuscitation performance, coordinative performance and defibrillator performance

	Unadjusted Results								Adjusted results [a]							Statistical parameters		
	Before intervention				After intervention				After intervention									
	Task1 control		Task 1 briefing		Task2 control		Task 2 briefing		Task 2 control		Task2 briefing		Difference in performance (intervention - control)			F	df	P
	M	SD	M	SD	M	SD	M	SD	M	SE	M	SE	M	Lower 95%CI	Upper 95%CI		53	
Hands-on performance	60.04	16.90	56.36	14.82	68.63	13.68	73.16	8.63	67.82	1.69	74.03	1.75	6.21	1.31	11.10			
Experience																32.91[c]	1	<0.001
Intervention																6.09[c]	1	0.017
Coordination performance	0.64	0.35	0.69	0.31	0.65	0.34	0.83	0.26	0.66	0.04	0.81	0.05	0.15	0.02	0.28			
Experience																35.77	1	<.0.001
Intervention																5.51	1	0.023
Defibrillation performance	65.50%[b]		74.10%[b]		0.50	0.31	0.47	0.30	0.50	0.06	0.47	0.06	-0.09	-0.27	0.09			
Experience																1.04	1	0.312
Intervention																0.19	1	0.663

Note: N=56 teams; [a] Adjusted for performance in task 1 (experience) [b] Experience for defibrillation performance represents whether the team defibrillated or not within task 1. [c] statistics are based on arcsine-transformation of performance scores. M= Mean, SD = Standard Deviation, SE = Standard Error; CI = Confidence Interval

DISCUSSION

A three-minute self-led post- briefing after a resuscitation task increased performance in a subsequent, similar task in ad-hoc teams of fourth-year medical students as compared to teams in a control group discussing other issues. Results are adjusted for performance in the first task, which therefore cannot explain the results.

The briefing enhanced basic hands-on and coordination performance, but not defibrillation performance. Hands-on performance represents basic aspects of resuscitation, and is particularly affected if teams have problems initiating the resuscitation or if interruptions occur. [34] Coordination performance also represents basic coordinative aspects of the task, as it measures the correct number of chest compressions and ventilation and their appropriate alternation. We therefore conclude that the briefing positively influenced basic aspects of task performance.

Although experienced task difficulty depends to some degree on the individual, defibrillation performance can be regarded as representing performance of more complex [35] and more advanced aspects of the task; it was not improved by the briefing. Two reasons may explain this result. First, the briefing instructions specifically asked the teams to reflect on their previous experience. As about half of the teams did not attempt defibrillation in task 1, defibrillation may not have been discussed in these teams during the briefing if they followed the instruction to reflect on their past experience. Second, other studies did not find effects of reflective briefings on performance if briefings were not combined with additional information or feedback, [36] [17] not led by an expert, [33] or if teams were not trained in reflecting.[19] Other authors also emphasized that the quality of (self-led) debriefings is often low.[37] Such aspects are likely to increase in importance as the complexity of tasks increases. It could thus be that the quality of the briefings was sufficient to increase basic aspects of performance, but not more complex ones. Particularly the latter aspect can be addressed in the expert-led debriefing after the simulator session.[38]

Self-led briefings without an expert may not only have positive effects, as there is a risk that erroneous information may be discussed and negatively influence subsequent performance[5]: Unfortunately, we have no information about the content of the reflective briefing and therefore cannot assess the accuracy of the information discussed. As an approximate test to identify potential negative effects of briefings, we compared the proportion of groups with decreasing performance in the second task as compared to the first task across conditions. Hands-on as well as coordinative performance was both worse in 2/27 (7.4%) of teams in the briefing condition, but in 7/29 (24.1%; hands-on) and 6/29 (20.7%; coordinative) of teams in the control condition; these differences did not reach conventional statistical significance levels. These results do not rule out negative effects of briefings, but they do indicate that negative effects may be the exception and may be offset by the positive effects of the briefing as compared to no briefing. Note that for defibrillation performance, such an analysis could not be done, as many teams did not defibrillate in the first tasks.

This study has limitations. First, it is an experimental study based on a cohort of fourth-year medical students. Although they represent relatively unexperienced medical professionals quite well, real ad-hoc resuscitation teams are likely to be interdisciplinary and composed of professionals with different levels of experience; this limits the generalizability of the results to medical practice. In addition, because participants are from the same cohort, we cannot control for the effects of prior training experiences they may have together. Another limitation is the relatively small sample size. Furthermore, we did not have information on the content of the briefing discussions; therefore, we could not assess the accuracy and level of expertise of the briefing discussion, nor to what degree the teams in the briefing condition may have addressed specific performance shortcomings in task 1. Further studies should investigate the content of such briefings.

[5] We thank one of the reviewers for emphasizing this aspect.

CONCLUSIONS

Learning how to reflect on one's own teamwork and task performance is an important skill;[39] in the optimal case, this skill is itself part of a training. This study shows that in simulation training, teams are capable to engage in self-led debriefings and profit from them, albeit in a limited way, that is, for basic aspects mainly. Evidently, the self-led debriefing is part of the simulation experience and should be discussed in the post-simulation expert expert-led briefing [33 38] to assure that all relevant aspects were discussed accurately, but also to discuss the process and potential difficulties of a self-led briefing.

For everyday practice, the results underscore the utility of even very short self-led post-task briefings. The mean length of post-action debriefings in trainings has been shown in a meta-analysis to be 17 minutes.[40] Although they may be more effective than shorter ones, such long briefings constitute major interruptions of ongoing work, and therefore are not very likely to be implemented into everyday practice. Our study showed that engaging in a three-minute briefing increased performance on a subsequent similar task by 6 percentage points for basic hands-on performance and by 15 percentage points for coordinative performance. Such a cost-effective and feasible intervention may thus be worthwhile to introduce. The debriefing instructions to look back at the task, analyze what went well and what did not, and to develop plans for a similar task, could well be used in everyday practice. To avoid negative effects of inaccurate knowledge, teams should be encouraged to look up information or seek expert advice if they detect knowledge gaps or insecurities during the briefings.

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