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Trainees' surgical activity and opportunity to transfer after simulation-based training

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ABSTRACT

Introduction: Simulation-based surgical training (SBST) is predicated on the assumption that trainees transfer their acquired skills and competencies into the operating room. Research on transfer of surgical training has focused on trainees' performance improvements and not on their actual opportunity to transfer their trained skills.

Methods: This was a retrospective study conducted using data on surgical procedures performed by first-year trainees in abdominal surgery, gynaecology and urology in the Central Denmark Region. We included data on trainees who participated in two different SBST courses; open surgery and laparoscopic surgery from 2014 to 2018.

Results: Data on a total of 127 first-year trainees were included. Our results revealed considerable variation in the number of procedures performed by first-year trainees in the three specialities. Comparing surgical activity after and before the SBST courses, we found median differences between 0 and 3, indicating no consistent increases in trainees' surgical activity in the post-course periods (five out of six comparisons were insignificant ($p > 0.05$)).

Conclusions: Trainees' surgical exposure varies within specialities and this may have consequences for achieving uniform levels of competence among trained specialists. Our results suggest that trainees do not have timely opportunities to intensify their clinical surgical activities after participating in SBST courses. A delay in opportunities to perform may inhibit the trainee's use of acquired skills and competencies and hamper transfer of training.

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Trial registration: not relevant.

Transfer of training is the application of knowledge and skills acquired in a training environment into the work environment. Simulation-based surgical training (SBST) is predicated on the assumption that trainees transfer the skills they learn in the simulated environment into the operating room (OR). Studies have shown that proficiency-based SBST leads to improved performance in the OR and to fewer surgical complications [1-3]. However, in addition to performance improvements, transfer of training involves the application, generalisation and maintenance of trained knowledge and skills through workplace-based activities [4, 5]. The adapted model of the transfer process points to three main training inputs that have proven to affect transfer of training: 1) Trainee characteristics, 2) Training design and 3) Work environment [5, 6]. Literature on transfer of training state that the effectiveness of training depends largely on the transfer climate in the work environment where trainees should apply their acquired knowledge and skills [7]. Support, follow-up and opportunity to perform in the work environment are strongly related to the transfer process [5].

This paper examines the surgical activity of Danish first-year trainees within three specialities. Aiming to study the trainees' timely opportunity to perform, we investigated differences in their clinical surgical activity, comparing periods after participation in SBST courses to periods before. Our hypothesis is that the trainees' ability to transfer the surgical skills acquired in SBST courses risk being hampered if the work environments do not provide sufficient and timely opportunities to intensify workplace-based surgical activities in the post-course periods.

METHODS

A retrospective study was conducted using register-based data on surgical procedures performed by first-year trainees in abdominal surgery, gynaecology and urology.

Context of the study

Since 2005, the Minimally Invasive Development Centre (MiUC) has offered SBST courses to surgical trainees in the Central and Northern Denmark Regions. Two courses were aimed at first-year trainees in abdominal surgery, gynaecology and urology: an open surgery course and a laparoscopic surgery course. In the directives on learning objectives issued by the Danish Health Authority, SBST is recommended as part of the training of first-year trainees in the three specialities [8]. The MiUC courses were originally designed to follow some of the best practices of SBST, allowing trainees to engage in deliberate practice with instructor feedback, and using validated tools for operative assessment [9, 10]. The open surgery course was a two-day course with dry-lab exercises on the first day and exercises on anaesthetised pigs on the second day. The laparoscopic course was offered as two modules: initially, a two-day module with exercises on black boxes and virtual reality models and subsequently a three-day module with more advanced exercises on anaesthetised pigs. The courses included assessments of skills and a brief interview as part of the feedback to the trainees. However, there were no clearly defined passing criteria or formal approval of the trainees' skills and competencies.

Participants and data collection

The study participants were first-year trainees in abdominal surgery, gynaecology and urology employed in the Central Denmark Region who participated in the open surgery course and/or the laparoscopic surgery course in the 2014-2018 period. Data on the trainees' surgical procedures were drawn from a business intelligence (BI) portal, which is a backend of the electronic patient records. We collected data on types of procedures, dates of procedures and the trainees' role. Data were merged with data on trainees' employment periods and the dates on which they participated in the SBST courses.

Data analysis

We included all procedures in which first-year trainees were registered as surgeon at the attending level. In our analyses of the trainees' characteristics and surgical activity during their first year of specialist training, we used data from their first employments. When estimating the surgical activity during the first year of training, we excluded data on trainees with employment periods shorter than 329 days (n = 18) based on the 10% allowable absence from a one-year training position. We present the number of procedures performed within the first 365 days of employment. Eligible breaks in employments were taken into account in our analyses.

When analysing surgical activity in correlation with the trainees' participation in the MiUC courses, we characterised the timely opportunity to intensify workplace-based surgical activities supporting transfer as a significant increase in the number of performed procedures 30 days after the course compared with 30 days before the course. These analyses were done regardless of previous employments and/or breaks in employments. Because the open surgery course was a generic course, we included all types of procedures in our analyses of surgical activity in correlation with that course. For the laparoscopic course, we only included laparoscopic procedures and based our analyses on the periods surrounding module two.

Analyses were stratified by speciality. Differences of non-paired data were analysed using the Wilcoxon-Mann-Whitney test and differences of paired data were analysed using the Wilcoxon signed-rank test. $p < 0.05$ was considered statistically significant. Results are reported as medians with interquartile ranges, with p-values reflecting differences in surgical activity.

Trial registration: not relevant.

RESULTS

We collected data on 127 first-year trainees (50 in abdominal surgery, 52 in gynaecology and 25 in urology). The median age at first employment was 30 (29-31) years. There was an uneven gender distribution with 66% women and 34% men (**Table 1**). Trainees participated in the open surgery course after 112 (57-189) days of employment, and in module two of the laparoscopic course after 187 (106-254) days.

TABLE 1 / Characteristics of the included trainees.

	Abdominal surgery ($N_a = 50$)	Gynaecology ($N_g = 52$)	Urology ($N_u = 25$)	Total ($N_{tot} = 127$)
Age at employment, yrs, median (IQR)	30 (29-31)	30 (29-31)	30 (29-33)	30 (29-31)
Sex, n (%)				
Men	20 (40)	12 (23)	11 (44)	43 (34)
Women	30 (60)	40 (77)	14 (56)	84 (66)
Hospital type, n (%)				
University hospital	8 (16)	9 (17)	17 (68)	34 (27)
Regional hospital	42 (84)	43 (83)	8 (32)	93 (73)

IQR = interquartile range

Surgical activity during the first year of training

First-year trainees were registered as surgeon in 90 (56-109), 122 (91-143) and 261 (210-277) procedures in abdominal surgery, gynaecology and urology, respectively. For laparoscopic procedures, trainees were registered as surgeon in 39 (26-54), 15 (10-19) and 0 (0-1) procedures in abdominal surgery, gynaecology and urology, respectively. As can be seen from **Figure 1**, we found large interindividual variations in the number of procedures performed by first-year trainees within the different specialities. Trainees in abdominal surgery employed at regional hospitals were registered as having performed significantly more total procedures ($p = 0.02$) and laparoscopic procedures ($p = 0.01$) than trainees at university hospitals. For gynaecology and urology, differences between the two hospital types were not significant. The most frequent non-endoscopic procedures performed by first-year trainees were inguinal hernia repair (14 (7-22)), Caesarean section (43 (34-66)) and circumcision (11 (1-17)) in abdominal surgery, gynaecology, and urology respectively. For laparoscopy, the most frequently performed procedures were laparoscopic cholecystectomy (14 (6-18)) in abdominal surgery and laparoscopic sterilisation (8 (1-10)) in gynaecology.

Surgical activity in correlation with course participation

Figure 2 shows the differences in the total number of procedures between the periods after and before the open surgery course. The median difference was 0 (–3-4) for abdominal surgery (p = 0.56) and 3 (–5-17) for urology (p = 0.16). For gynaecology, the median difference was 3 (0-7), and this increase (despite being small) was significant (p < 0.001). We found no statistically significant differences comparing laparoscopic surgical activity after and before module two of the laparoscopic surgery course (**Figure 3**). The median difference was 0 (–2-2) for abdominal surgery (p = 0.94), 0 (–1-1) for gynaecology (p = 0.92) and 0 (0-0) for urology (p = 0.08).

FIGURE 1 / Total number of procedures (A) and number of laparoscopic procedures (B) during the first year of training by speciality and hospital type. Lines representing median with boxes depicting interquartile range.

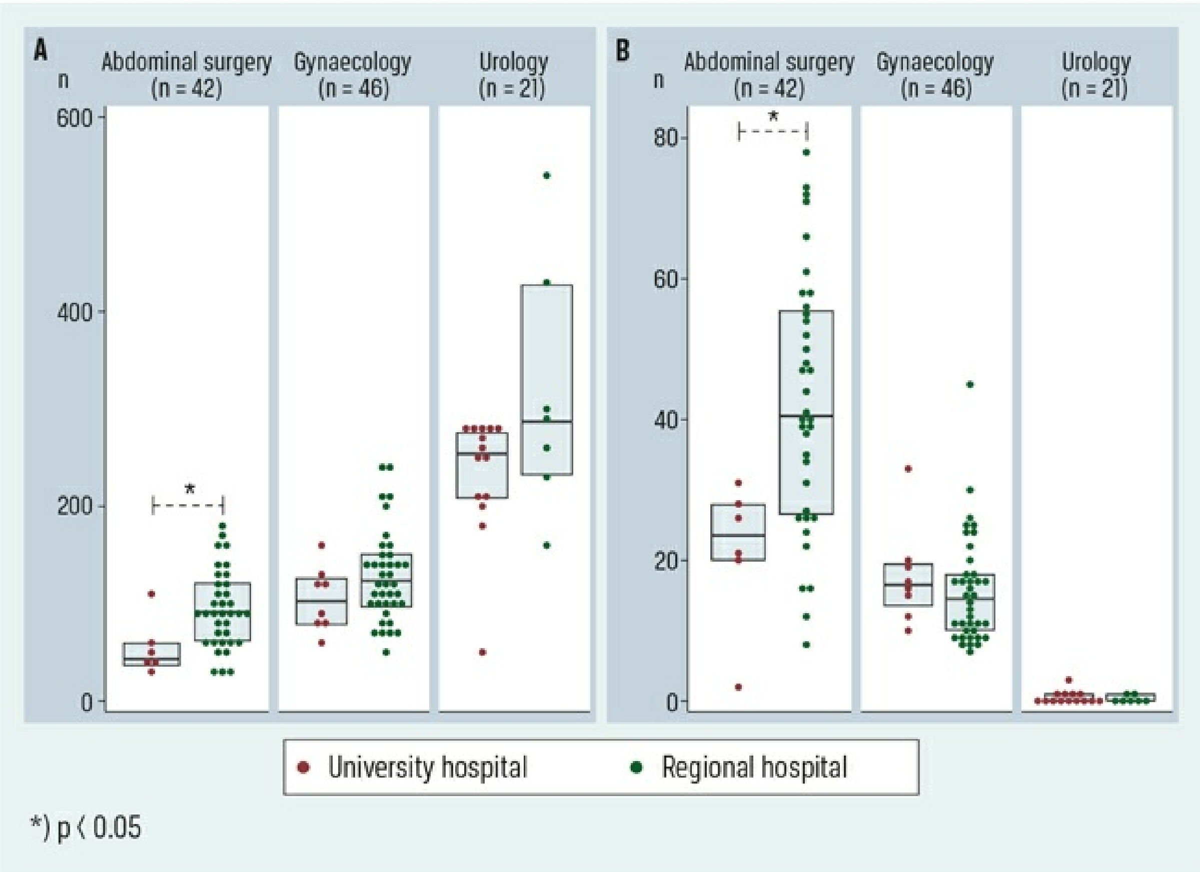


FIGURE 2 / Differences in number of procedures between 30 days after and 30 days before the open surgery course for each speciality. Lines representing median with boxes depicting interquartile range.

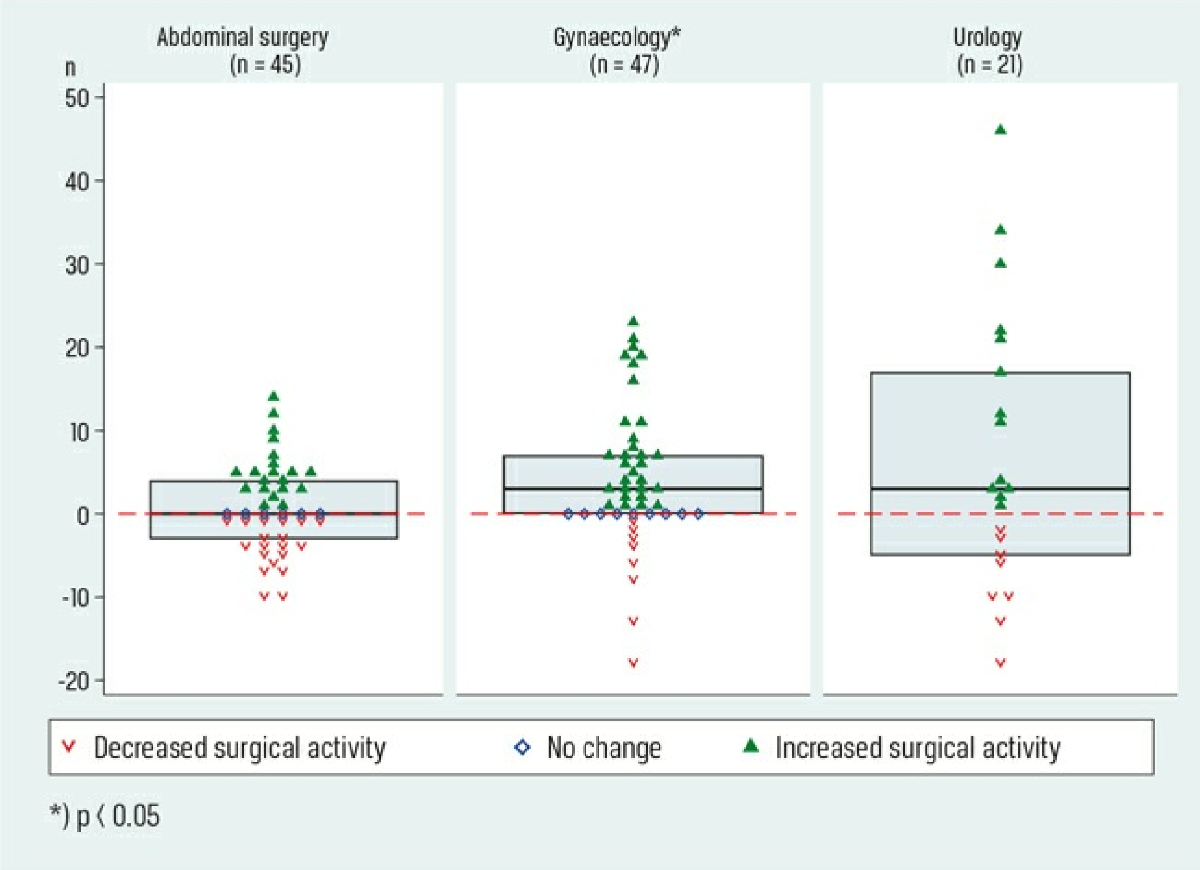
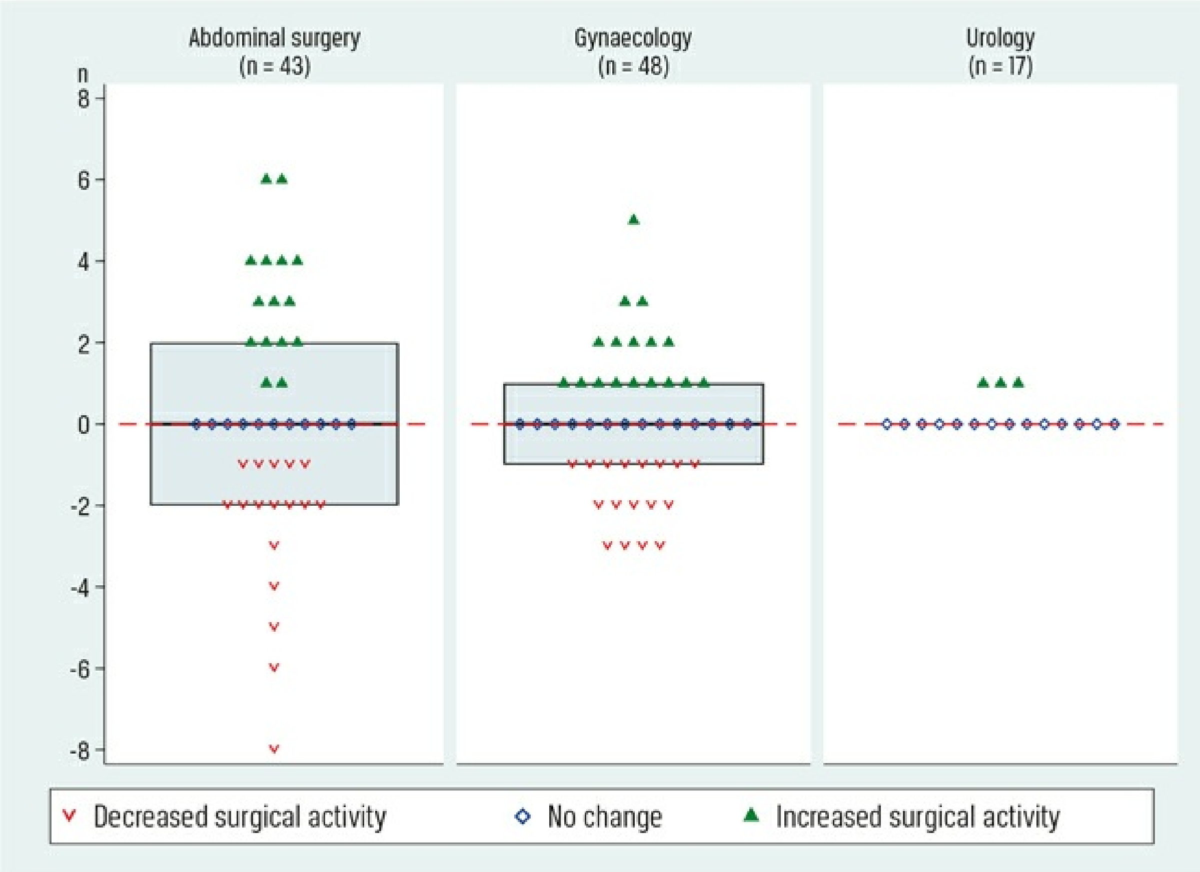


FIGURE 3 / Differences in number of laparoscopic procedures between 30 days after and 30 days before the laparoscopic surgery course for each speciality. Lines representing median with boxes depicting interquartile range. No significant differences between periods after and before the course.



DISCUSSION

One aim of our study was to assess first-year trainees' opportunity to perform in the OR in the post-course periods by investigating the timely correlation between surgical activity and trainees' participation in SBST courses. Our analyses suggested no systematic timely correlations and, more importantly, no consistent increase in trainees' surgical activity in the 30-day post-course periods. This contrasts with literature which emphasises that the post-training phase provides a window of opportunity to enhance learning and argues that delaying opportunities to perform may negatively impact the transfer process [5, 11, 12]. This highlights the importance of a positive transfer climate that prompts the use of newly acquired skills. On the contrary, negative transfer climates can lead to reduced motivation, lack of confidence and failure to transfer [7]. Translated into the context of surgical training and education, the transfer climate at the clinical departments may have important implications for the trainees' professional development, and this may ultimately influence patient safety.

We found large variations in the duration of periods between start of employment and course participation. We argue that the timing of course participation should reflect the opportunities to perform in the clinical setting, which does not seem evident from our findings. Curriculum integration and range of difficulty are important for effective learning through SBST [13]. Ensuring coherent training programmes that allow trainees to progressively engage in training of increasing difficulty yields increased motivation, accelerated learning and higher skill levels [14].

In accordance with previous findings, we found considerable variation in the number of procedures performed by trainees in the three specialities [15]. This skewness in clinical surgical training may reflect organisational differences (e.g., department size, number of trainees, subspecialisation, etc.) and differences in patient demography. In addition, it may also reflect differences in trainee characteristics and work environments. Large variations in surgical volume may be counterproductive to the aim of educating trainees to the same levels of competence. However, the association between surgical volume and surgical competence is continuously debated. Some studies suggest that factors involved in the educational work environment are more important to the development of surgical expertise than surgical volume [16, 17]. In regards to transfer of training, it is noteworthy that despite their participation in a comprehensive laparoscopic course, first-year trainees in urology hardly perform any laparoscopic procedures during their first year of training. However, the fact that first-year trainees in urology may assist laparoscopic and robot-assisted laparoscopic procedures may justify their participation in the basic module of the course.

The main limitation of this study is that the validity of the data from the BI portal was not assessed. The BI portal contains data recorded in the electronic patient records by clinicians and secretaries. Thus, data might be subject to information bias, which might have led to non-differential inaccuracy in the estimates of the trainees' surgical activity. We saw indications in the data that the trainees' role as assistants may have been under-registered. This was the reason for not including these data. However, we expect the registration of attending surgeons to be more accurate, especially since patient records are legal documents that may serve as evidence of the care provided. Still, the limitations of this data source warrant discussion. In many other countries, electronic surgical portfolios have been implemented in post-graduate surgical training [18]. Portfolios allow trainees to monitor their own progression and make it easier for supervisors to provide feedback. Portfolios help encourage practice-based learning and increase personal responsibility for learning [19]. Thus, from an educational point of view, it is problematic that there is no common and mandatory surgical portfolio available to Danish trainees. A second limitation was that we were only able to collect data on trainees employed in the Central Denmark Region and only for trainees who participated in the MiUC courses. As a control group, it would have been interesting to include data on trainees who did not participate in the courses. Finally, our study only investigated one of the inputs known to influence the transfer process, namely the opportunity to perform within the work environment, which is arguably the first step to ensure transfer. However, transfer of training is influenced by many factors and it is well established that support and follow-up (e.g., supervision, feedback and assessment) are key influential factors in the transfer process and in surgical training in general [5, 14, 20].

Future research should investigate facilitators and barriers to transfer of surgical training. Investigating the effects of integrating course- and work-based training and implementing a supervised surgical portfolio may potentially contribute positively to this endeavour.

CONCLUSIONS

Our study confirms that large variations exist in surgical exposure between first-year trainees and reveals no consistent correlation between trainees' SBST course activities and their work-based surgical activities. In a Danish context, good clinical work environments exist that have the potential to provide good transfer processes. However, we argue that organisational unawareness and lack of structural integration between course- and work-based training may be counterproductive to trainees' training efforts and opportunity to transfer.

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