



# BMJ Open Effects of a management team training intervention on the compliance with a surgical site infection bundle: a before–after study in operating theatres in the Netherlands

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## ABSTRACT

**Objectives** To assess the effects of a quality improvement (QI) team training intervention, by measuring the intervention fidelity and the compliance with a surgical site infection (SSI) bundle in the operating theatre (OT).

**Design** Multicentre before–after study.

**Setting** This study was performed in four Dutch hospitals.

**Intervention** The QI team training intervention consisted of four sessions per hospital and stimulated participants to set culture norms and targets, identify barriers, and formulate management activities to improve compliance with four standard operating procedures (SOPs) of a SSI bundle in the OT. Participants were executive board members, top-level managers, leading clinicians and support staff. The four SOPs were: (1) reducing door movements; (2) preoperative antibiotic prophylaxis prescribing; (3) preoperative shaving; and (4) postoperative normothermia. *Poisson* and logistic regression analyses were performed to analyse the effect of the intervention on compliance with the individual SOPs (primary outcome measure) and on the influence of medical specialty, time of day the procedure took place and time in the OT (secondary outcome measures).

**Results** Not all management layers were successfully involved during all sessions in the hospitals. Top-level managers were best represented in all hospitals, leading clinicians the least. The number of implemented improvement activities was low, ranging between 2 and 14. The team training intervention we developed was not associated with improvements in the compliance with the four SOP of the SSI bundle. Medical specialty, time of day, and time in OT were associated with median number of door movements, and preoperative antibiotic prophylaxis administration.

**Conclusion** This study showed that after the QI team training intervention the overall compliance with the four SOPs did not improve. Minimal involvement of leading clinicians and a low number of self-initiated activities after the team training were important barriers for compliance.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This is a multicentre study, including two university teaching hospitals, a large general hospital and a small general hospital.
- ⇒ The QI team training intervention is based on four behavioural models.
- ⇒ Direct observations, the gold standard, were used to collect data regarding safety practice in the operating theatre.
- ⇒ Limitations of this study are the small number of participating hospitals, the small number of observed procedures and the uncontrolled before–after design.

## BACKGROUND

Despite growing attention for patient safety, adverse events are still common in hospital care worldwide. Review studies show a median overall incidence of 10%, of which more than 50% could be prevented.<sup>1–3</sup> Next to surgery or medication-related procedures, healthcare-associated infections are the most common adverse events in hospital care.<sup>1–3</sup> This includes surgical site infections (SSIs), which are largely preventable when a bundle of standard operating procedures (SOPs) are followed before, during and after surgery.<sup>4–6</sup> The number and type of measures included in a SSI bundle can vary considerably, but some measures are mentioned more often.<sup>7</sup> These measures are focused on surgical-site preparation, hair removal, antibiotic prophylaxis, wound closure, normothermia and glycaemic control.<sup>7–10</sup>

The compliance with measures to prevent SSI, however, has a wide range and can vary per measure.<sup>7 11–13</sup> Therefore, in the Netherlands, a bundle of SOP was implemented as part of the national Dutch Hospital Patient Safety (DHPS)

programme.<sup>14 15</sup> This programme aimed to improve patient safety and prevent adverse events, and facilitated the participating hospitals by providing training, practical guidelines and interventions. Evaluation of the DHPS programme showed that a successful implementation of a SSI bundle depended on human, organisational and topic-related factors, including a perceived need for implementation of the topic and involvement of management.<sup>14</sup> International patient safety experts emphasise the importance of focusing on both individual and organisational factors to improve the patient safety.<sup>16 17</sup> Improving a poor patient safety culture is important since this has been associated with adverse events.<sup>18 19</sup> Professional involvement, leadership, collaboration and engagement at all management levels in an organisation are considered paramount and crucial to be able to improve patient safety, including infection prevention.<sup>20–24</sup>

Changing organisational factors could be achieved by using team training interventions, which are specifically developed to get all management levels and stakeholders in an organisation involved.<sup>16 18 25 26</sup> Team training interventions have a strong focus on formulating organisational norms and goals and stimulating collaboration with different departments, which could potentially lead to a faster implementation of patient safety measures.<sup>10 27</sup> However, current team training interventions often focus on one medical specialty or do not involve all important stakeholders, or only involve one management level in a hospital.<sup>16 28 29</sup> We developed a novel quality improvement (QI) team training intervention, which includes all management levels in the organisation. We assessed the effects of this organisational intervention, by measuring the intervention fidelity and the compliance with a SSI bundle in the operating theatre (OT).

## METHODS

### Study design

This multicentre before–after study was performed, between June 2014 and July 2015, in the OTs of four hospitals in the Netherlands.

### Study population

The participating hospitals consisted of two university teaching hospitals (ie, hospitals 1 and 2), a large general hospital (ie, hospital 3) and a small general hospital (ie, hospital 4) (table 1). The four hospitals were selected in order to include the full range of hospital levels in the Netherlands and was based on their joint grant application for this study. The non-sterile OT personnel of different medical specialties (eg, surgery, gynaecology, oral surgery, Ear Nose Throat, neurosurgery, ophthalmology, orthopaedics, plastic surgery, urology) were observed.

### Patient and public involvement

No patient involvement.

### Intervention

The aim of the QI team training intervention was to involve all management levels in the hospital and facilitate collaboration between these management levels, during the implementation of a patient safety intervention (ie, the four SOPs of the SSI bundle).

Each hospital formed a core team, consisting of an executive board member and one or two top-level managers. This core team was part of an improvement team, consisting of 8–10 members with key positions in the prevention of SSI. These members were chosen by the core team from all management layers and disciplines in the hospital. Participants of the improvement teams were (1) members of the executive board, (2) top-level managers (eg, directors, department heads, unit heads, managers, team leaders), (3) leading clinicians (eg, surgeons, surgeon assistants, anaesthesiologists and nurse anaesthetists, medical microbiologist) and (4) support staff (eg, quality advisors, infection control specialist and IT employees).

The QI team training intervention builds on social cognitive theory (ie, human behaviour is a product of intrapersonal, behavioural and environmental determinants),<sup>30</sup> social influence theory (ie, appropriate performance is

**Table 1** Characteristics hospitals

Hospital	Type of hospital	Hospital beds	Baseline		Postintervention	
			Number of observed procedures	Median OT time (range)	Number of observed procedures	Median OT time (range)
1	University teaching hospital	1125	72	1:12 hours (0:06 hours–3:43 hours)	118	0:59 hours (0:05 hours–3:42 hours)
2	University teaching hospital	1300	69	1:13 hours (0:05 hours–3:45 hours)	89	0:46 hours (0:04 hours–3:12 hours)
3	Large general hospital	481	70	0:38 hours (0:04 hours–3:49 hours)	94	0:30 hours (0:02 hours–3:26 hours)
4	Small general hospital	161	81	0:48 hours (0:05 hours–3:33 hours)	86	0:42 hours (0:03 hours–3:32 hours)
Total (median)	–	–	<b>292 (71)</b>	<b>0:54 hours (0:04 hours–3:49 hours)</b>	<b>387 (92)</b>	<b>0:46 hours (0:02 hours–3:42 hours)</b>

OT, operating theatre.

defined by the social norms in the network),<sup>31</sup> theory on team effectiveness (ie, orientation on team climate, willingness to change and working towards a common goal)<sup>31 32</sup> and leadership theory (ie, leading, coaching and managing a team).<sup>33 34</sup>

These four behavioural theories form the basis of the QI team training intervention and were reflected in the various sessions. The various sessions were described by use of the Behaviour Change Technique Taxonomy (v1) by Michie *et al.*<sup>35</sup> The focus of the first joint kick-off meeting (session 1) with all four hospitals was on goal setting (outcome), commitment and comparative imagining of future outcomes (ie, social influence theory, social cognitive theory, leadership theory). In this meeting, the influence from the managers on the compliance with the SSI bundle was discussed. The target audience was the core team from each hospital. In the second session, organised per hospital, the focus was on action planning (ie, theory on team effectiveness) and identifying factors that had to be performed before implementing the four SOPs. The third session, organised per hospital, focused on reviewing behaviour and outcome goals. Based on this, clear agreements, objectives and action points were formulated to meet the requirements of the four SOPs (ie, all four behavioural theories). The fourth (optional) session was only executed in hospital 2. In this session, extra attention was given to monitoring and feedback, and comparison of outcomes (ie, leadership theory). There was a final joint session with all four participating hospitals, with the focus on natural consequences and comparison of outcomes. All sessions were moderated by a team of behavioural experts without a link to the participating hospitals.

### Outcomes

We assessed intervention fidelity and the compliance with the four SOPs of a SSI bundle, measured at baseline and postintervention. The four SOPs were: (1) reducing OT door movements, (2) preoperative antibiotic prophylaxis prescribing, (3) preoperative shaving and (4) postoperative normothermia (online supplemental file 1, criteria SOP). Selection of the four SOPs was based on the study of van den Broek *et al.*<sup>36</sup> The study of van den Broek *et al* reviewed available literature, already established performance indicators and international campaigns (eg, Safer Healthcare Now! (Canada), 100 000 Lives and 5 Million Lives (USA) and High Five Safety Programme (WHO)).

### Data collection

To put the QI team training intervention into practice, it was decided to implement four SOPs of a SSI bundle. The focus of the sessions was on the different steps that had to be taken to implement and comply to these four SOPs. To investigate whether the QI team training had any effect, change in compliance with the four SOPs was measured. Compliance was observed by trained students (ie, 6 at baseline, 10 postintervention) through unobtrusive observations in the OT. The students reported for

each procedure data in an observation checklist (online supplemental file 2). Inclusion criteria were planned surgical procedures of less than 4 hours and involving adults (18+). Exclusion criteria were emergency surgery, planned surgical procedures of more than 4 hours (due to limitations in project resources) and procedures involving children.

### Statistical analysis

Besides descriptive analyses, regression analyses were performed. We first assessed the effect of the QI team training intervention on the compliance with the four SOPs. The four SOPs were the primary outcome measure in these models. To ensure that possible clustering was taken into account, the variables ‘hospital’ and ‘measuring moment (baseline or postintervention)’ were included in all analyses as fixed effect.

Subsequently, as secondary outcome measure, we assessed the influence of ‘medical specialty’, ‘time of day the procedure took place (<12:00 hours or ≥12:00 hours)’ and ‘time in the OT’ on the number of door movements (*Poisson* regression) and on antibiotic prophylaxis (*logistic* regression).

Associations were considered statistically significant at  $p < 0.05$  for multivariable analyses. In these multivariable analyses, we included all parameters with  $p < 0.20$  in the univariable analyses. All data were analysed using SPSS software V.25 (IBM, Armonk, New York).

## RESULTS

Compliance with the four SOPs was observed at baseline (June–October 2014,  $n=292$  procedures) and postintervention (June–July 2015,  $n=387$  procedures) (table 1). At baseline, a median of 71 procedures per hospital were observed, with a median procedure time of 0:54 hours (range: 0:04 hours–3:49 hours). Postintervention, a median of 92 procedures per hospital were observed, with a median procedure time of 0:46 hours (0:02 hours–3:42 hours). Based on the observed procedures, 10 medical specialties could be distinguished of which general surgery was the most commonly observed (baseline: 31%, postintervention 25%) (online supplemental file 3).

### Intervention fidelity

The intention to involve all management layers during all sessions was not successful in all hospitals. In hospital 1, a member of the executive board only participated in the first session but not in the other three sessions (table 2). Furthermore, the top-level managers were best represented in all hospitals during all sessions. Involvement of leading clinicians was low in all hospitals, especially in hospitals one and four.

The number of implemented improvement activities at the end of the intervention, ranged between 2 and 14, and was low for most hospitals, except for hospital 2 ( $n=14$ ) (table 2). The hospitals focused on different improvement activities during the intervention, but

**Table 2** Members and activities of the improvement teams

	Hospital 1 University teaching hospital				Hospital 2 University teaching hospital				Hospital 3 Large general hospital				Hospital 4 Small general hospital			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
<b>Members of improvement teams</b>																
Executive board member	1	0	0	N.A.	1	1	1	1	1	1	1	N.A.	1	1	1	N.A.
Top-level managers	1	7	4	N.A.	1	5	4	3	0	5	5	N.A.	1	3	2	N.A.
Leading clinicians	1	1	0	N.A.	0	1	3	3	0	2	3	N.A.	0	1	0	N.A.
Support staff	0	6	4	N.A.	0	0	1	1	1	2	1	N.A.	0	2	1	N.A.
<i>Total number of members present</i>	3	14	8	N.A.	2	7	9	8	2	10	10	N.A.	2	7	4	N.A.
<b>Category of implemented improvement activity</b>	<b>Hospital 1</b>				<b>Hospital 2</b>				<b>Hospital 3</b>				<b>Hospital 4</b>			
Change of policy	0				5				2				0			
Communication	1				1				1				2			
IT	0				2				1				1			
Audits and reports	0				3				0				0			
Education	0				2				0				1			
Working group established	1				0				0				1			
Facilities	0				1				0				0			
<i>Total number of implemented improvement activities</i>	2				14				4				5			

IT, information technology; N.A., not applicable; S, Session.

change of policy, communication and IT were the most common subjects to focus on among all hospitals. Change of policy activities included formulate agreements on taking breaks and leaving the OT, evaluating the time-out principle, clarify policy on cap use in the OT and merging different protocols on hair removal. Communication and IT included creating a newsletter or poster in the OT, updating patient flyers and making adaptations to IT software with regard to the SSI bundle.

### Compliance with SSI bundle

The team training intervention we developed was not associated with significant improvements in the compliance with the four SOPs of the SSI bundle. The overall number of door movements per hour (OR: 1.39, 95% CI: 1.25 to 1.55) and overall compliance with postoperative normothermia guidelines (OR: 0.54, 95% CI: 0.32 to 0.89) showed a significant deterioration after the intervention (table 3). Only hospital 2 showed an individual improvement of more than 10% on compliance with post-operative normothermia guidelines.

Multivariable *Poisson* regression analyses showed that the independent variables ‘medical specialty’, ‘time of day the procedure took place (<12:00 hours or ≥12:00 hours)’, and ‘time in the OT’ were significantly associated with the overall median number of door movements (table 4). The medical specialties orthopaedics (OR: 0.60, 95% CI: 0.54 to 0.67), ophthalmology (OR: 0.71, 95% CI: 0.63 to 0.80) and plastic surgery (OR: 0.84, 95% CI: 0.75 to 0.93) had significant less door movements compared with the medical specialty general surgery

(table 4). Procedures after 12:00 hours had a significant higher odds of 1.10 (95% CI: 1.05 to 1.16) of more door movements compared with procedures before 12:00 hours. For every extra minute in the OT, the odds of more door movements significantly increased with 1.95 (95% CI: 1.88 to 2.02).

The multivariable logistic regression analysis of preoperative antibiotic prophylaxis administration showed that the medical specialty orthopaedics had significantly more odds (OR: 6.02, 95% CI: 1.31 to 27.69) of being compliant with preoperative antibiotic administration, compared with the medical specialty general surgery (table 5).

No regression analysis was performed on preoperative shaving, because the non-compliance group was too small. Additionally, we did not report the regression analyses of normothermia, because only the variable ‘specialism’ was significant in the univariable analysis and therefore no multivariable analysis could be performed.

### DISCUSSION

This study showed that after the QI team training intervention no overall improvement was observed for the four hospitals on compliance with a SSI bundle. Only hospital 2 showed a modest improvement of more than 10%, on the compliance with postoperative normothermia guidelines. Intervention fidelity of this study was low, with minimal involvement of leading clinicians and a low number of implemented improvement activities.



**Table 3** Compliance with surgical site infection bundle

Standard operating procedure		Hospital				Total	OR (95% CI)	P value
		1	2	3	4	Total		
Median (range) number of door movements per hour*	Baseline	15 (0–52)	7 (0–60)	7 (0–28)	5 (0–30)	8 (0–60)		
	Postintervention	14 (0–66)	9 (0–123)	6 (0–150)	6 (0–150)	8 (0–150)		
	+/-	-1	+2	-1	+1	0	1.39 (1.25 to 1.55)	<0.001
No. (%) compliance with preoperative AB prophylaxis guideline	Baseline	41 (91%)	28 (80%)	27 (87%)	73 (95%)	169 (90%)		
	Postintervention	84 (84%)	58 (77%)	67 (84%)	54 (96%)	263 (85%)		
	+/-	-7%	-3%	-3%	+1%	-5%	0.77 (0.43 to 1.38)	0.38
No. (%) compliance with preoperative shaving guideline	Baseline	72 (100%)	66 (96%)	66 (94%)	78 (96%)	282 (97%)		
	Postintervention	117 (100%)	83 (100%)	88 (100%)	84 (100%)	372 (100%)		
	+/-	0%	+4%	+6%	+4%	+3%	N.A.†	N.A.†
No. (%) compliance with postoperative normothermia guideline	Baseline	27 (69%)	16 (67%)	‡	63 (91%)	106 (80%)‡		
	Postintervention	71 (62%)	62 (80%)	‡	51 (64%)	184 (68%)‡		
	+/-	-7%	+13%	‡	-27%	-12%	0.54 (0.32 to 0.89)	0.02

\*The absolute number of door movements between incision and closing of the wound during a procedure, has in this table been converted to number of door movements per hour to correct for length of procedure.

†The compliance with preoperative shaving guidelines was already high at baseline and postintervention, the non-compliance group was too small to perform regression analyses on.

‡Hospital 3 was excluded from the analysis of this specific SOP since they chose to follow their own guideline and not the recommended guideline. This implied that they did not take the temperature of patients who had procedures of <30 min.

AB, antibiotic; CI, Confidence Interval; N.A., not applicable; No, number; OR, Odds Ratio; SOP, standard operating procedure.

Our study showed a large variability between baseline and postintervention compliance with the four SOPs, for the hospitals together and on individual hospital level. Only compliance with preoperative shaving increased

over time, but this was not significant. Both preoperative antibiotic prophylaxis and postoperative normothermia showed a decrease in compliance, which was significant for normothermia. This could potentially be due to the

**Table 4** Poisson regression analysis of the determinants of the number of door movements

Variable	OR (95% CI) in univariable analysis	P value	OR (95% CI) in multivariable analysis	P value
<b>Medical specialty</b>				
Surgery	1.00		1.00	
Gynaecology	1.29 (1.18–1.41)	<0.001	1.20 (1.10–1.32)	<0.001
Oral surgery	1.27 (1.14–1.40)	<0.001	1.15 (1.03–1.27)	0.01
ENT	1.01 (0.91–1.13)	0.80	1.07 (0.96–1.19)	0.21
Neurosurgery	1.62 (1.47–1.78)	<0.001	1.31 (1.19–1.45)	<0.001
Ophthalmology	0.65 (0.57–0.74)	<0.001	0.71 (0.63–0.80)	<0.001
Orthopaedics	0.64 (0.57–0.71)	<0.001	0.60 (0.54–0.67)	<0.001
Plastic surgery	0.77 (0.70–0.86)	<0.001	0.84 (0.75–0.93)	<0.001
Urology	1.06 (0.96–1.17)	0.25	0.99 (0.90–1.09)	0.81
Other*	1.93 (1.75–2.12)	<0.001	1.77 (1.61–1.95)	<0.001
<b>Time of day</b>				
<12:00 hours	1.00		1.00	
≥12:00 hours	0.97 (0.92–1.02)	0.19	1.10 (1.05–1.16)	<0.001
<b>Time in the OT</b>	2.00 (1.93–2.07)	<0.001	1.95 (1.88–2.02)	<0.001

\*Thorax/trauma/vascular surgery.  
CI, confidence interval; ENT, Ear Nose Throat; OR, odds ratio; OT, operating theatre.

**Table 5** Logistic regression analysis of the determinants of the compliance with preoperative antibiotic prophylaxis guidelines

Variable	OR (95% CI) in univariable analysis	P value	OR (95% CI) in multivariable analysis	P value
<b>Medical specialty</b>				
Surgery	1.00	0.04	1.00	0.03
Gynaecology	0.97 (0.39–2.43)	0.94	1.01 (0.40–2.55)	0.99
Oral surgery	0.61 (0.19–1.95)	0.40	0.57 (0.18–1.83)	0.35
ENT	0.75 (0.21–2.64)	0.65	0.75 (0.21–2.64)	0.65
Neurosurgery	1.32 (0.38–4.54)	0.66	1.35 (0.39–4.68)	0.64
Ophthalmology	1.78 (0.34–9.33)	0.50	1.65 (0.31–8.69)	0.56
Orthopaedics	5.84 (1.27–26.81)	0.02	6.02 (1.31–27.69)	0.02
Plastic surgery	2.44 (0.77–7.73)	0.13	2.52 (0.79–8.02)	0.12
Urology	0.47 (0.20–1.10)	0.08	0.45 (0.19–1.08)	0.07
Other*	1.64 (0.54–5.00)	0.39	1.66 (0.54–5.09)	0.37
<b>Time of day†</b>	1.49 (0.86–2.58)	0.16	1.65 (0.93–2.91)	0.09
<b>Time in the OT</b>	0.89 (0.65–1.22)	0.46	N.A.	N.A.

\*Thorax/trauma/vascular surgery.

†Reference group is <12:00 hours

CI, confidence interval; ENT, Ear Nose Throat; N.A., not applicable; OR, odds ratio; OT, operating theatre.

short intervention period and might have been higher with multiple measurements over a longer period of time. Van der Slegt *et al.*<sup>11</sup> implemented the same SSI bundle on a surgical ward in one hospital and showed that the compliance per SOP fluctuated per measuring moment, but additionally showed that an increase in compliance on all four SOPs was reached after an extended period of 2 years.<sup>11</sup> The challenges faced when improving compliance and the time it takes to change behaviour is also reported by von Lengerke *et al.*<sup>37</sup>

We did not report on bundle compliance for two reasons. First, for the bundle element 'number of door movements', there is no scientific cut-off point to calculate compliance. There is only the recommendation to minimise number of door movements during surgical procedures.<sup>38</sup> Second, healthcare professionals at one of the four hospitals systematically did not measure patients' temperatures during procedures lasting <30 min. They felt this was neither feasible nor necessary. This resulted in very low compliance with the specific bundle element. Presenting overall bundle compliance may lead to unintended conclusions since it is largely influenced by one specific bundle element.

The disappointing intervention fidelity and the low number of implemented improvement activities per hospital might also have influenced the compliance with the four SOPs. Overall the top-level managers were best represented in all hospitals and the leading clinicians the least. Several studies endorse the importance of including a senior leader or executive for achieving organisational change.<sup>16 18 27</sup> However, including more healthcare professionals who have to perform the new SOP (eg, the leading clinicians) might improve the compliance with a SSI bundle on the work floor. Furthermore, hospital 2 implemented the most improvement activities (n=14)

and was the only hospital with an increase in compliance of more than 10%. However, hospital 2 also mentioned that they already had a clear decision-making structure in their hospital including different management layers, which might have resulted in a faster implementation of the new intervention. This could suggest that this type of intervention has the greatest chance of success when a hospital already has a clear decision-making structure and a good safety culture.

Furthermore, involvement of more leading clinicians during the implementation of the intervention could have prevented the significant decrease in compliance (of 12%) in our study with the postoperative normothermia guideline. Leading clinicians could have indicated at the start of the intervention, that measuring patient's temperature with procedures lasting <30 min is not feasible. Since the SOP is evidence-based and used in other studies,<sup>7 39</sup> the members of the improvement team together with the leading clinicians could have formulated an option that was feasible for the work floor but also ensured compliance with the SOP. Adjusting the moment of taking the temperature could make it more feasible for example to incorporate the SOP in the workflow and might increase the compliance with the SOP.

This study has a number of strengths and limitations. First, to our knowledge this is the first study to investigate the effects of a team training intervention programme, including different management levels in the hospital. As part of this strength, we were able to include members of the executive board in the improvement teams. Inviting participants on behalf of the executive board showed to be an extra incentive to participate. As another strength, we collected data regarding safety practices in the OT through direct observation, which is considered the golden standard. We were able to observe 679 procedures,

with a median length of almost 1 hour. Since procedures often take a long time, multiple direct observations in the OT are very labour-intensive and extensive data are therefore currently lacking.

Limitations of this study are the small number of participating hospitals, the small number of observed procedures and the uncontrolled before–after design. This study was a non-controlled before–after study, which means that if we had found better compliance with the SSI bundle after the intervention, still no conclusions on causal relationships could be drawn. Implementation of a randomised controlled trial and including more hospitals, could prevent this in future studies.<sup>40</sup> However, applying the same method of direct in-depth observations on such a large scale, might be less feasible and could come with financial or logistic difficulties. Furthermore, even though the data used are from 2014 and 2015, low compliance with care bundles still reflects practice today.<sup>12</sup>

To conclude, this study showed no overall improvement in compliance with a SSI bundle after a team training intervention, including all management levels in the hospital. Minimal involvement of leading clinicians and a low number of self-initiated activities after the team training intervention were important barriers for compliance. These barriers should be taken into account before implementing this type of intervention.

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**Patient consent for publication** Not applicable.

**Ethics approval** The study protocol has been approved by the Medical Ethics Board of the Erasmus MC University Medical Centre Rotterdam, the Netherlands. In the Netherlands it is not necessary to collect informed consent from health care workers before observing their behaviour, although all participating hospitals were informed about the study prior to commencement.

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## Additional file 1. Criteria of the Standard Operating Procedures of the Surgical Site Infection-bundle

SOP	Recommendation guideline (1, 2)	How it was observed
OT door movements	Reducing/minimizing the number of door movements during an procedure.	Counting the number of door movements between incision and closing of the wound.
Preoperative antibiotic prophylaxis prescribing	When indicated, medication should be given 15-60 minutes before incision, with an optimal of 30 minutes before incision.	No medication indicated, I. Medication is given to early (>60 min), II. Medication is given in time (15-60 min), or III. Medication is given to late (<15 min)
Preoperative shaving	No shaving by default, but only on indication. When indicated, shaving should be done right before the incision and by using a clipper with disposable head.	Is the patient shaved (yes/no), if yes, what is the location and method of shaving.
Postoperative normothermia	Measure temperature of the patient during closure of the wound. The temperature should be between 36.0-38.0 °C when measured rectal and non-rectal between 35.5-37.5 °C.	Is the patient's temperature measured (yes/no), if yes, how is the temperature measured, what is the time of measurement and what is the temperature.

Abbreviations: SOP, Standard Operating Procedures; OT, Operating Theatres; WHO, World Health Organization.

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## Additional file 2. Observation checklist “Compliance with a SSI intervention bundle”

Item	Answer Categories
Hospital name	1 2 3 4
Date	
Surgical Specialty	
Surgical procedure	
Is this procedure an indicator for DHPS programme?	1 = Yes 2 = No 3 = Unknown
Patient ID	
Time patient arrived at OT	
Time start OT procedure (incision)	
Number of door movements between incision and closure (count)	
Were there any unforeseen circumstances?	1 = Yes 2 = No 3 = Unknown
Specify unforeseen circumstances	
Time of administration of antibiotic prophylaxis	
Where was antibiotic prophylaxis administered?	1 = Ward 2 = Operating theatre 3 = OT holding area 4 = Other 5 = Unknown
Which antibiotic prophylaxis was administered	
Was the operation area shaved?	1 = Yes 2 = No 3 = Unknown
Where was the patient shaven?	1 = OT 2 = Ward 3 = Unknown
If the patient was shaven in the OT, which device was used?	1 = Clipper 2 = Blade 3 = Hair removal cream 4 = Unknown
If a clipper was used, did this have a disposable shaving cap?	1 = Yes 2 = No 3 = Unknown
What time was the patient shaven?	
Was the patients temperature measured?	1 = Yes 2 = No

	3 = Unknown
How was the temperature measured?	1 = Ear thermometer 2 = Temperature probe 3 = Arterial line 4 = Nasally 5 = Pharyngeally 6 = Other
When was the temperature measured?	
What was the measured temperature?	
Were any measures taken to hypothermia?	1 = Yes 2 = No 3 = Other
If so, when?	1 = Before 2 = During 3 = After
If so, how?	1 = Warm air blanket 2 = Heat bandage 3 = Warm sheets 4 = Heated IV fluids 5 = Cap or socks during operation 6 = Normal blanket 7 = Others
Where does laying-up instruments take place?	1 = OT 2 = Separate room 3 = Unknown
Does laying-up instruments take place under air flow?	1 = Yes 2 = No 3 = Unknown
Which other activities are taking place in the same area during laying-up instruments?	
Are instruments covered after being set out?	1 = Yes 2 = No 3 = Surgery starts directly
Function employee	1 = Anesthetist 2 = Anesthetic nurse
Is the uniform worn correctly?	1 = Yes 2 = No 3 = Unknown



If not, what is incorrect	1 = Clothing visible under scrub suit 2 = Clothing is worn over scrub suit; 3 = Face mask not worn; 4 = Face mask not worn correctly 5 = Surgical cap not worn; 6 = Surgical cap not worn correctly
Is jewellery worn?	1 = Yes 2 = No 3 = Unknown
If yes, what?	1 = earrings 2 = necklace 3 = bracelet 4 = watch 5 = ring
Is the number of door movements mentioned during time-out?	1 = Yes 2 = No 3 = Unknown
What is the time of closure?	
What time did patient leave OT?	
Any remarks?	
Type of hand hygiene moment	1 = Moment 1: Before patient contact 2 = Moment 2: Before an aseptic task 3 = Moment 3: After body fluid exposure risk 4 = Moment 4: After patient contact 5 = Moment 5: After contact patient environment
Function employee	1 = Anesthesist 2 = Anesthetic nurse
Hand hygiene performed?	1 = Alcohol based hand rub 2 = Hand washing 3 = No hand hygiene
Gloves worn?	1 = On 2 = Off

Abbreviations: SSI, Surgical Site Infection; DHPS programme, Dutch Hospital Patient Safety program; ID, identification; OT, operating theatre.

**Additional file 3. Number of procedures per medical specialty**

Medical specialty (N, %)	Hospital 1		Hospital 2		Hospital 3		Hospital 4		Total	
	Baseline	Post-intervention	Baseline	Post-intervention	Baseline	Post-intervention	Baseline	Post-intervention	Baseline	Post-intervention
Surgery*	8 (11%)	11 (9%)	7 (10%)	16 (18%)	27 (39%)	33 (35%)	49 (60%)	37 (43%)	91 (31%)	97 (25%)
Gynaecology	4 (6%)	11 (9%)	5 (7%)	9 (10%)	11 (16%)	9 (10%)	16 (20%)	5 (6%)	36 (12%)	34 (9%)
Oral surgery	14 (19%)	8 (7%)	6 (9%)	4 (4%)	-	-	-	2 (2%)	20 (7%)	14 (4%)
ENT**	5 (7%)	13 (11%)	14 (20%)	-	-	1 (1%)	2 (2%)	14 (16%)	21 (7%)	28 (7%)
Neurosurgery	6 (8%)	10 (8%)	6 (9%)	5 (6%)	-	4 (4%)	6 (7%)	2 (2%)	18 (6%)	21 (5%)
Ophthalmology	8 (11%)	21 (18%)	5 (7%)	-	-	-	-	-	13 (4%)	21 (5%)
Orthopaedics	11 (15%)	12 (10%)	6 (9%)	5 (6%)	14 (20%)	25 (27%)	-	13 (15%)	31 (11%)	55 (14%)
Plastic surgery	9 (13%)	15 (13%)	8 (12%)	29 (33%)	3 (4%)	-	1 (1%)	2 (2%)	21 (7%)	46 (12%)
Urology	7 (10%)	10 (8%)	5 (7%)	9 (10%)	11 (16%)	8 (9%)	7 (9%)	11 (13%)	30 (10%)	38 (10%)
Other***	-	7 (6%)	7 (10%)	12 (13%)	4 (6%)	14 (15%)	-	-	11 (4%)	33 (9%)
<b>Total</b>	<b>72 (100%)</b>	<b>118 (100%)</b>	<b>69 (100%)</b>	<b>89 (100%)</b>	<b>70 (100%)</b>	<b>94 (100%)</b>	<b>81 (100%)</b>	<b>86 (100%)</b>	<b>292 (100%)</b>	<b>387 (100%)</b>

\* Surgery includes general surgery and abdominal surgery; \*\* Ear-, Nose-, and Throat surgery; \*\*\* Others include: thorax-, trauma-, and vascular surgery.