ORIGINAL ARTICLE

Contribution of Prior, Multiple-, and Repetitive Surgeries to the Risk of Surgical Site Infections in the Netherlands

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OBJECTIVE. Surveillance is an important strategy to reduce the incidence of surgical site infections (SSIs). We investigated whether prior, multiple-, or repetitive surgeries are risk factors for SSI and whether they should be preserved in the protocol of the Dutch national SSI surveillance network.

METHODS. Dutch national SSI surveillance data 2012–2015 were selected, including 34 commonly performed procedures from 8 major surgical specialties. Definitions of SSIs followed international standardized criteria. We used multivariable multilevel logistic regression techniques to evaluate whether prior, multiple-, or repetitive procedure(s) are risk factors for SSIs. We considered surgeries clustered within partnerships of medical specialists and within hospitals (random effects) and different baseline risks between surgical specialties (fixed effects). Several patient and surgical characteristics were considered possible confounders and were included where necessary. We performed analyses for superficial and deep SSIs combined as well as separately.

RESULTS. In total, 115,943 surgeries were reported by 85 hospitals; among them, 2,960 (2.6%) resulted in SSIs (49.3% deep SSIs). The odds ratio (OR) for having prior surgery was 0.94 (95% confidence interval [CI], 0.74–1.20); the OR for repetitive surgery was 2.39 (95% CI, 2.06–2.77); and the OR for multiple surgeries was1.27 (95% CI, 1.07–1.51). The latter effect was mainly caused by prolonged duration of surgery.

CONCLUSIONS. Multiple- and repetitive surgeries significantly increased the risk of an SSI, whereas prior surgery did not. Therefore, prior surgery is not an essential data item to include in the national SSI surveillance network. The increased risk of SSIs for multiple surgeries was mainly caused by prolonged duration of surgery, therefore, it may be sufficient to report only duration of surgery to the surveillance network, instead of both (the variables duration of surgery and multiple surgeries).

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Surgical site infections (SSIs) are among the most common healthcare-associated infections (HAIs), and they occur in approximately 3% of all surgical patients.[1,2] The highest incidence of SSI has been described in colorectal surgery, with incidence rates as high as 30%.[3–7] The cumulative incidence of SSI varies by the type of surgical procedure, by hospital, and by the quality of data collection; it also depends on the criteria used to define the infection.[8,9] SSIs are a major concern because they lead to increased morbidity and mortality, longer hospital stays, and higher costs.[10,11] In addition, the emergence of antibiotic-resistant strains, the increased use of nonhuman implants in surgical procedures, and an ageing patient population with high morbidity are making infection prevention practices more complicated.[12–14]

Surgical site infection surveillance is an essential step in identifying local problems and priorities and in evaluating the effectiveness of infection prevention activities.[15] Research has shown that SSI surveillance results in enhanced infection prevention control actions and interventions leading to a significant reduction of SSIs.[16,17] In the Netherlands, the Dutch surveillance network for healthcare-associated infections PREZIES (the Dutch acronym for 'PREventie van ZIEkenhuisinfecties door Surveillance') monitors the cumulative SSI incidence and SSI risk factors.[18]

Within the PREZIES network, patient-related, procedure-related, and postoperative risk factors are collected for a set of index-surgeries to interpret national trends and comparisons between hospitals (Table 1).[12] Some risk factors, however, are presumed rather than established risk factors. For instance, the variables 'prior surgery,' 'multiple surgical procedures,' and 'repetitive surgeries' are included in the surveillance network, but their direct association with the occurrence of SSIs has not yet been adequately studied (Table 1).

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TABLE 1. Definitions as Used in the PREZIES Protocol of the Dutch Surgical Site Infection (SSI) Surveillance[a]

Index Surgery

The first (or primary) surgery to an organ or body structure (ie, bone, joint, vessel) ever. Restricted to a list of 34 surgical procedures (see Table S1). Previous minimally invasive procedures to the same organ or body structure as the index surgery (eg, keyhole surgeries, biopsies, or stent insertions) are allowed

If a patient has 2 different surgical procedures performed at the same time, only 1 surgical procedure is included in the surveillance. The surgeon decides which procedure serves as the index surgery.

Prior Surgery

Small, minimally invasive procedures to the same organ or body structure (ie, bone, joint, vessel) as the index surgery, performed during the 1 year prior to the index surgery. Other examples include keyhole surgeries, biopsies, or stent insertions, as well as meniscectomy prior to total knee replacement and insertion of a pacemaker prior to coronary artery bypass grafting

Additionally, for abdominal procedures, any small or large surgical procedure performed during the 1 year prior to the index surgery, not to the same organ or body structure (ie, joint or vessel) as the index surgery but still in the abdominal region. For example, a cesarean section 6 months prior to a colectomy is reported as a prior surgery

Multiple Surgery(ies)

Additional surgical procedures performed during the index surgery, performed in the same surgical area as the index surgery (ie, through the same incision), eg, tubal ligation performed during cesarean section

Repetitive Surgery

A surgical procedure, for any reason other than SSI, within the follow-up period of the index surgery, performed in the same surgical area as where the index surgery has been performed (through or just next to the old incision). Examples include dislocation following total hip replacement and anastomotic leakage following colectomy

[a]Reprinted from the PREZIES protocol (2014, version 1.0).[18]

Because the workload related to data collection for surveillance is burdensome, it is essential to incorporate only important risk factors that are easy to measure. Doing so would not only result in a reduced workload for hospital personnel but also would improve the willingness of healthcare facilities to participate in the surveillance network. In this study, we investigated whether prior, multiple-, and repetitive surgeries are relevant risk factors for SSIs, and we sought to determine whether data pertaining to these factors should continue to be collected in the Dutch national surveillance network.

MATERIALS AND METHODS

Participants and Data Collection

For this observational cohort study, we used PREZIES SSI surveillance data from January 2012 to January 2015. Details of the surveillance have been described previously.[19,20] In short, the PREZIES surveillance database contains prospectively collected data of 34 commonly performed surgical procedures (ie, so-called index surgeries, supplementary Table S1) of 8 major surgical specialties: cardiovascular, breast, gastrointestinal, vascular, orthopedic surgeries, gynecology, neurosurgery, and cosmetic surgery.[18,19] For each surgical procedure under surveillance, data concerning the patient, surgery, and infection were collected in a prospective manner according to the surveillance protocol by trained infection prevention professionals and medical microbiologists.[17,18] Retrospective on-site validation was performed by the PREZIES team.[18] Hospitals can report the causative microorganism; however, this is not mandatory because the diagnosis of SSI can be based on clinical symptoms alone (Table 2). Participation in the surveillance network is voluntary for all healthcare facilities in the Netherlands, including university hospitals, general hospitals, and private medical centers (hereafter, cumulatively referred to as hospitals). In addition, hospitals are free to choose when and how long they participate in the surveillance network and which surgical procedures they report.

Due to the increase in outpatient care, same-day surgery and shorter hospitalizations, many SSIs develop post discharge.[20–23] To detect postdischarge SSIs, 2 standardized methods of postdischarge surveillance were chosen by PREZIES and were mandatory.[20,22,24] For all surgeries included in surveillance, a follow-up period of 30 days was required. This follow-up period was extended to 1 year for deep SSIs if a nonhuman implant was used. The surveillance ended (1) if the follow-up period was completed; (2) if a deep SSI was diagnosed; or (3) if the patient died.

Definitions and Outcome

In total, 34 types of index surgeries can be included for surveillance. The definition of an index surgery is given in Table 1.[18] Operation types with at least 100 completed records were included.

The risk factors under investigation in this study were 'prior surgery,' 'multiple surgical procedures,' and 'repetitive surgery.' Detailed definitions for these variables are summarized in Table 1.[18] In short, prior surgery is a surgery performed within 1 year prior to the index surgery. Multiple surgical procedures refer to an additional surgical procedure performed during the index surgery. In case of multiple index surgeries, the designation of the primary index surgery is left to the discretion of the surgeon. Repetitive

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TABLE 2. Definitions Used to Diagnose Surgical Site Infections in the Dutch Surgical Site Infection (SSI) Surveillance[a]

Superficial Incisional SSI

Infection occurs within 30 days after surgery; infection involves only skin or subcutaneous tissue of the incision, and at least 1 of the following:

1. Purulent drainage from the superficial incision
2. At least 1 of the following signs or symptoms: pain or tenderness, localized swelling, erythema, or heat, AND microorganisms are isolated from an aseptically obtained culture from the superficial incision.
3. At least 1 of the following signs or symptoms: pain or tenderness, localized swelling, erythema, or heat, AND the superficial incision is deliberately opened by the surgeon (not applicable if culture-negative incision)

Deep Incisional SSI

Infection occurs within 30 days after surgery if no implant is left in place, or within 1 year if an implant is in place and the infection is related to the surgery. Infection involves deep soft tissues (eg, fascial and muscle layers) of the incision and at least 1 of the following:

1. Purulent drainage from the deep incision, excluding organ-space[b]
2. An abscess or other evidence of infection involving the deep soft tissues is found on direct examination, during repetitive operation, or by histopathologic or radiological examination[c]
3. At least one of the following signs or symptoms: pain or tenderness, localized swelling, erythema, heat, or fever (>38°C), AND a deep incision that spontaneously dehisces or is deliberately opened by a surgeon (a culture-negative finding does not meet this criterion)[d]

Organ-Space SSI[c]

Infection occurs within 30 days after surgery if no implant is left in place or within 1 year if an implant is in place. Infection involves any part of the anatomy (eg, organs or organ spaces) that was opened or manipulated during an operation and at least 1 of the following:

1. Purulent drainage from a drain that is placed through the stab wound into the organ/space
2. An abscess or other evidence of infection involving organ-space, which is found on direct examination, during repetitive surgery, or by histopathologic or radiological examination
3. Microorganisms isolated from an aseptically obtained culture from the organ/space[d]

[a]Reprinted from the PREZIES protocol (2014, version 1.0).[18]
[b]Report infection that involves both superficial and deep incision sites as a deep incisional SSI.
[c]Report an organ-space SSI that drains through the incision as a deep incisional SSI.
[d]Not applicable for colectomy followed by anastomotic leakage or perforation.

surgeries are defined as a reoperation for any reason other than an SSI.

The primary end point of this study was the cumulative incidence of SSI as defined by criteria from the (European) Centers for Disease Control and Prevention ((E)CDC), translated and modified by PREZIES (Table 2).[18,25–27] Organ-space and deep SSIs are grouped under the umbrella term 'deep SSI' because, in practice, it is difficult to distinguish deep SSIs from organ-space SSIs.[18,28] In this study, 3 outcomes were considered. The first outcome was the cumulative incidence of SSIs (total), which indicates the development of an SSI regardless of the type of infection (deep or superficial). In addition, as secondary outcomes, we used the incidences of superficial SSIs and deep SSIs, respectively, to determine whether risk factors are different for these types of infection.[8,29,30]

Statistical Analyses

Results are reported as medians and means for continuous variables and as frequencies and proportions for categorical variables. Box-and-whisker-plots were generated to describe the distribution of SSIs for the 8 selected specialties.

We used multivariable multilevel logistic models to estimate the odds of an SSI due to prior, multiple-, or repetitive surgeries. We considered possible clustering of the data by adding random effects of the combination of surgical specialty and hospital, thereby creating partnerships of surgical specialties within hospitals. Surgical specialty was added as a fixed effect to the model to correct for the baseline differences in SSI risk per type of surgical specialty. Possible confounders were selected based on literature and clinical judgment and were tested using a stepwise forward selection method. If a covariate changed the odds ratio (OR) by 10% or more, this variable was considered a confounder and was included in the final model. For all 3 potential risk factors, the following possible confounders were considered: age, gender, body mass index (BMI), normal body temperature during the surgery (normothermia), wound class, American Society of Anaesthesiologists (ASA) class, malignancy, and the use of an implant in surgery. In addition, for the analyses focusing on prior surgery and repetitive surgery, the possible confounder duration of surgery was also investigated. In addition, for repetitive surgery, the variables prior surgery and multiple surgeries were considered additional potential confounders; for multiple surgeries, the possible influence of prior surgery and repetitive surgeries was examined. For multiple surgeries, the influence of the duration of surgery was additionally analyzed because, with more operational procedures in 1 session, the operation time is likely to be longer. Therefore, we investigated the extent to which the relationships among these factors could influence the results. Odds ratios and 95% confidence intervals (95% CI) were calculated for the 3 outcomes: total SSI, superficial SSI, and deep SSI.

For the sensitivity analysis, the analyses for superficial and deep SSIs were repeated after excluding breast surgeries. Because it is notoriously difficult to distinguish superficial SSIs from deep SSIs in breast surgeries without implants, the results of analyzing deep and superficial SSIs separately may not be reliable for this specialty. Therefore, we repeated the separate analyses for deep and superficial infections excluding all breast surgeries.

Descriptive analyses were performed using SPSS version 22.0 software (SPSS, Chicago, IL). The multivariable multilevel models were analyzed using SAS version 9.3 software (SAS Institute, Cary, NC). A P value $\leq .05$ was considered statistically significant.

RESULTS

In total, 115,944 surgeries were reported between January 2012 and January 2015 in the PREZIES database. Only surgical procedures reported more than 100 times were included for analysis, resulting in the inclusion of 115,943 surgeries of 7 specialties reported by 85 hospitals. Among the included surgeries, 2,960 SSIs (2.6%) were diagnosed; 1,502 of these (50.7%) were superficial and 1,458 (49.3%) were deep SSIs. In 1,170 deep SSIs (80.2%) and 906 superficial SSIs (60.3%), a causative organism was reported.

Table 3 shows the baseline characteristics for the included surgeries, stratified by the 3 investigated risk factors. Box-and-whisker-plots (Figure 1) illustrate SSI incidences for each surgical specialty. The highest SSI incidences were found in gastrointestinal surgery, followed by vascular and breast surgery. For vascular operational procedures, 2 hospitals had exceptionally high infection rates (24.5% and 25.0%) but had reported only 49 and 20 surgeries, respectively (data not shown).

Data regarding prior surgery were available for 108,618 patients. Of 3,511 patients with a prior surgery, 87 (2.5%) developed an SSI, compared to 2,757 of 105,107 patients without prior surgeries (2.6%). Prior surgery was more often performed on women, due to the high number of cesarean sections and hysterectomies. We found no significant association between prior surgery and the development of SSIs (either deep, superficial or both combined [ie, total SSIs]), and no confounders were detected (Table 4).

Having had multiple surgeries during the index surgery was positively associated with prior surgery, repetitive surgery, suspicion of malignancy, and an increased mean duration of surgery. Of 3,542 patients with multiple surgeries, 178 (5.0%) developed an SSI, compared to 2,782 of 112,401 (2.5%) in the group without multiple surgeries. An increased OR of developing an SSI was found for patients having multiple surgeries, which was significant for deep SSIs and all SSIs combined (OR, 1.48; 95% CI, 1.17–1.88; OR, 1.27; 95% CI, 1.07–1.50, respectively) but was not statistically significant for superficial SSIs (OR, 1.14; 95% CI, 0.90–1.43). When excluding breast surgeries from the analyses, effects for deep and superficial SSIs became more similar; however, only the result for deep SSIs was statistically significant. After adjusting for duration of surgery in the models, no effect of multiple surgeries on deep SSIs, superficial SSIs, or both was found (OR range, 0.94–1.15, data not shown).

Of 115,943 patients, 3,013 underwent a repetitive surgery. In these patients, 236 (8.5%) developed an SSI compared to 2,724 of 112,930 patients (2.4%) in the group without repetitive surgery. For patients who developed an SSI, the median time to repetitive surgery was 6 days versus 13 days for people without an SSI ($P \leq .0001$). Most repetitive surgeries were reported for breast surgeries. Odds ratios for the relationship between repetitive surgeries and all SSI types (total), superficial SSIs, or deep SSIs were all significantly increased (OR range, 1.73–3.44) (Table 4). After excluding breast surgeries from the analyses, the effects were even stronger. Body mass index was found to confound the relationship between repetitive surgery and superficial SSIs.

DISCUSSION

The analyses show that multiple- and repetitive surgeries significantly increased the odds of SSIs: ORs were 1.27 and 2.31 for developing deep and superficial SSI combined respectively, and the OR was even larger for deep SSI. Having had a prior surgery did not, however, significantly increase the odds of SSI, so we concluded that prior surgery is not a risk factor for the development of SSI. Because retrieving information about prior surgery(ies) per patient is time-consuming and laborious, we consider it no longer worthwhile to report this variable in our surveillance system.

Patients with multiple procedures during the index surgery had increased odds of developing SSIs. When analyzing this association for superficial and deep SSIs separately, we observed a significantly increased and slightly larger risk for deep SSI compared to superficial SSI. When excluding breast surgeries from the analyses, effects found for deep and superficial SSIs became more similar; however, only the risk for deep SSI was statistically significant increased. A possible explanation could be that, with more procedures performed through the same incision during 1 surgery, more deep tissue is handled and damaged, resulting in a greater risk for deep SSI.[31] Another possibility is that the longer duration of the surgery rather than the secondary procedure itself (compared to patients with a single operation, ie, only the index surgery) is responsible for the higher odds. A longer duration of surgery has been associated with an increased risk of SSI,[5,7,30,32–35] and with more operational procedures in 1 session, time between incision and closure is likely to be longer. When we included duration or surgery in the model of multiple surgeries and superficial infections, no effect of multiple surgeries was found. Based on these findings, we concluded that multiple surgeries are an indirect risk factor for developing SSI, and therefore, the related data are useful data to report to the surveillance network. However, when duration of surgery is

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TABLE 3. Baseline Characteristics of Patients, Specified for Each of the Three Risk Factors Under Investigation

	Prior Surgery (n = 108,618), No. (%)[a,b]		Multiple Surgeries (n = 115,943), No. (%)[a]		Repetitive Surgeries (n = 115,943), No. (%)[a]	
Patient Characteristics	Yes	No	Yes	No	Yes	No
No. of patients	3,511 (3.2)	105,107 (96.8)	3,542 (3.1)	112,401 (96.9)	3,013 (2.6)	112,930 (97.4)
Age, median y (range)	61 (12–95)	65 (2–103)	63 (2–98)	65 (3–103)	66 (15–96)	65 (2–103)
Male gender	662 (18.9)	31,367 (29.8)	989 (27.9)	32,650 (29.1)	977 (32.4)	32,662 (28.9)
BMI, mean (± SD)	27.7 (±5.4)	27.7 (±5.1)	27.0 (±5.2)	27.8 (±5.2)	26.6 (±5.1)	27.8 (±5.2)
ASA classification	3,421 (97.4)	95,807 (91.2)	3,147 (88.8)	103,194 (91.8)	2,587 (85.9)	103,754 (91.9)
Low (I and II)	3,063 (89.5)	82,340 (85.9)	2,658 (84.5)	89,032 (86.3)	2,070 (80.0)	89,620 (86.4)
High (III, IV, and V)	358 (10.5)	13,467 (14.1)	489 (15.5)	14,162 (13.7)	517 (20.0)	14,134 (13.6)
Wound class	3,402 (96.9)	97,470 (92.7)	3,160 (89.2)	104,895 (93.3)	2,616 (86.8)	105,439 (93.4)
1	2,766 (81.3)	74,823 (76.8)	1,928 (61.0)	81,241 (77.4)	1,909 (73.0)	81,260 (77.1)
2	562 (16.5)	20,006 (20.5)	1,052 (33.3)	20,993 (20.0)	567 (21.7)	21,478 (20.4)
3	48 (1.4)	1,848 (1.9)	111 (3.5)	1,882 (1.8)	76 (2.9)	1,917 (1.8)
4	26 (0.8)	793 (0.8)	69 (2.2)	779 (0.7)	64 (2.4)	784 (0.7)
Malignancy	3,478 (99.1)	104,208 (99.1)	3,467 (97.9)	111,333 (99.0)	2,979 (98.9)	111,821 (99.0)
Yes	1,618 (46.5)	14,922 (14.3)	1,726 (49.8)	15,586 (14.0)	1,417 (47.6)	15,895 (14.2)
No	1,860 (53.5)	89,286 (85.7)	1,741 (50.2)	95,747 (86.0)	1,562 (52.4)	95,926 (85.8)
Prior surgery			3,378 (95.4)	105,240 (93.6)	2,889 (95.9)	105,729 (93.6)
Yes	NA	NA	566 (16.8)	2,945 (2.8)	228 (7.9)	3,283 (3.1)
No			2,812 (83.2)	102,295 (97.2)	2,661 (92.1)	102,446 (96.9)
Multiple surgeries	3,511 (100)	105,107 (100)			3,013 (100)	11,2930 (100)
Yes	566 (16.1)	2,812 (2.7)	NA	NA	294 (9.8)	3,248 (2.9)
No	2,945 (83.9)	102,295 (97.3)			2,719 (90.2)	109,682 (97.1)
Repetitive surgeries	3,511 (100)	105,107 (100)	3,542 (100)	112,401 (100)		
Yes	228 (6.5)	2,661 (2.5)	294 (8.3)	2719 (2.4)	NA	NA
No	3,283 (93.5)	102,446 (97.5)	3,248 (91.7)	109,682 (97.6)		
Surgery-Related Characteristics						
Specialty	3,511 (100)	105,107 (100)	3,542 (100)	112,401 (100)	3,013 (100)	112,930 (100)
Cardiovascular surgery	47 (1.3)	6,485 (6.2)	336 (9.5)	6,201 (5.5)	345 (11.4)	6,192 (5.5)
Breast surgery	1,501 (42.8)	9,845 (9.4)	1,164 (32.9)	10,830 (9.6)	1,062 (35.3)	10,932 (9.7)
Gastrointestinal surgery	394 (11.2)	19,141 (18.2)	982 (27.7)	19,567 (17.4)	694 (23.0)	19,855 (17.6)
Vascular surgery	47 (1.3)	1,793 (1.7)	188 (5.3)	1,757 (1.6)	110 (3.6)	1,835 (1.6)
Orthopaedic surgery	1,142 (32.5)	50,383 (47.9)	402 (11.3)	54,452 (48.4)	701 (23.3)	54,153 (47.9)
Gynaecological surgery	370 (10.5)	15,861 (15.1)	437 (12.3)	17,907 (15.9)	86 (2.9)	18,258 (16.2)
Neurosurgery	10 (0.3)	1,599 (1.5)	33 (0.9)	1,687 (1.5)	15 (0.5)	1,705 (1.5)
Duration of index surgery, mean min (± SD)	77.6 (±52.2)	76.1 (±42.6)	115.4 (±79.5)	75 (±40.4)	99.0 (±60.8)	77.5 (±42.3)
Implant	3,511 (100)	105,107 (100)	3,542 (100)	112,401 (100)	3,013 (100)	112,930 (100)
Yes	1,313 (37.4)	57,901 (55.1)	1,114 (31.5)	61,518 (54.7)	1,295 (43.0)	61,337 (54.3)
No	2,198 (62.6)	47,206 (44.9)	2,428 (68.5)	50,883 (45.3)	1,718 (57.0)	51,593 (45.7)
Normothermia	3,511 (100)	105,107 (100)	3,542 (100)	112,401 (100)	30,135 (100)	112,930 (100)
Yes	2,165 (61.7)	58,113 (55.3)	2,167 (61.2)	62,184 (55.3)	1,676 (55.6)	62,639 (55.5)
No	183 (5.2)	8,782 (8.4)	216 (6.1)	9,936 (8.8)	180 (6.0)	9,972 (8.8)
Not measured	1,163 (33.1)	38,212 (36.3)	1,159 (32.7)	40,317 (35.9)	1,157 (38.4)	40,319 (35.7)

NOTE. BMI, body mass index; SD, standard deviation; ASA, American Society of Anaesthesiologists; NA, not applicable.
[a]Unless otherwise indicated.
[b]Data were missing for 7,325 patients (6.3%) for prior surgery due to transfers between hospitals and incomplete patient records.

also reported to the surveillance network, it is worthwhile to consider discontinuing the reporting of multiple surgeries, especially because the duration of surgery is easier to interpret and to report. Additional research with more detailed information about multiple surgeries will be valuable to validate our findings.

Repetitive surgery is reported for SSI surveillance if a patient is reoperated on for any reason other than infection. This study showed that repetitive surgery is a risk factor for SSIs, and this might be explained by the fact that in repetitive surgeries the incision (or the area around the incision) is reopened, resulting in more scar tissue and new opportunities for skin flora to

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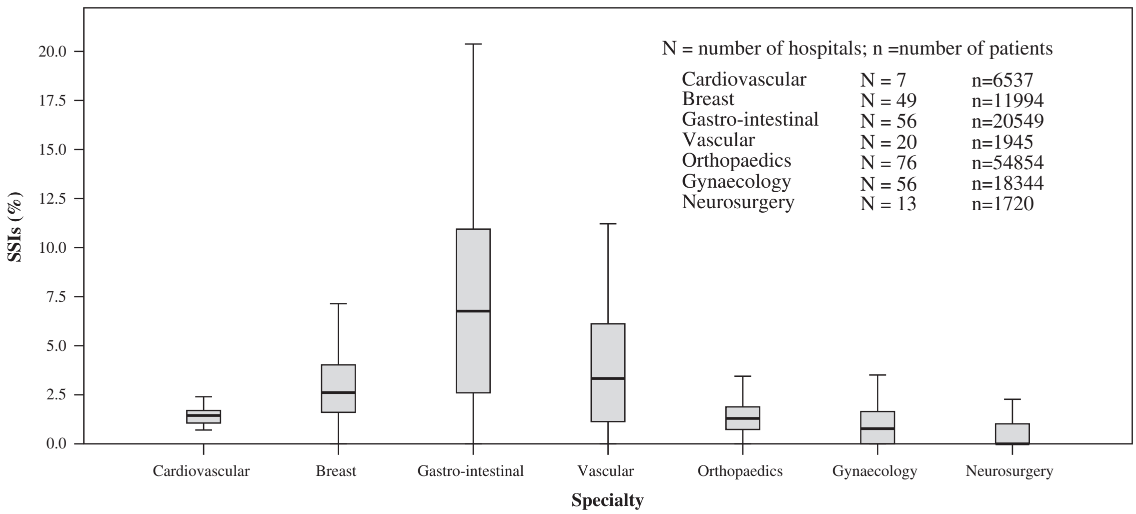

FIGURE 1. Distribution of surgical site infection incidence in hospitals per surgical specialty.

TABLE 4. Results of Multivariable Multilevel Analyses for Prior, Multiple, and Repetitive Surgery(ies) on the Outcomes of Total, Superficial, and Deep Surgical Site Infections (SSIs)

Prior Surgery				
	Yes (N = 3,511), No. (%)	No (N = 105,107), No. (%)	All Surgeries, OR (95% CI)	Excluding Breast Surgeries, OR (95% CI)
SSI (Total)	87 (2.4)	2,757 (2.6)	0.94 (0.74–1.20)	1.03 (0.79–1.36)
Superficial SSI	47 (1.3)	1,397 (1.3)	0.79 (0.56–1.10)	0.84 (0.55–1.28)
Deep SSI	40 (1.1)	1,360 (1.3)	1.12 (0.81–1.57)	1.25 (0.88–1.76)
Multiple Surgeries				
	Yes (N = 3,542), No. (%)	No (N = 112,401), No. (%)		
Total SSI	178 (5.0)	2,782 (2.5)	**1.27 (1.07–1.50)**	**1.31 (1.08–1.58)**
Superficial SSI	92 (2.6)	1,410 (1.3)	1.14 (0.90–1.43)	1.28 (0.94–1.65)
Deep SSI	86 (2.4)	1,372 (1.2)	**1.48 (1.17–1.88)**	**1.37 (1.06–1.78)**
Repetitive Surgery				
	Yes (N = 3,013), No. (%)	No (N = 112,930), No. (%)		
Total SSI	236 (7.8)	2,724 (2.4)	**2.31 (1.99–2.68)**	**2.99 (2.52–3.51)**
Superficial SSI	91 (3.0)	1,411 (1.2)	**1.62 (1.27–2.06)**[a]	**2.14 (1.63–2.82)**[b]
Deep SSI	145 (4.8)	1,313 (1.2)	**3.44 (2.85–4.14)**	**3.95 (3.26–4.79)**

NOTE. OR, odds ratio; 95% CI, 95% confidence interval.
[a]Adjusted for BMI. Non-adjusted OR = 1.57 (95% CI, 1.25–1.97).
[b]Adjusted for BMI. Non-adjusted OR = 1.99 (95% CI, 1.54–2.56).

invade the wound. Furthermore, we found that a higher BMI distorts the relation between repetitive surgeries and superficial SSIs.

Strengths and Limitations

To the best of our knowledge, this study is the first multicenter study investigating the effect of prior, multiple-, and repetitive surgeries on SSI, including several surgical specialties. A major strength of this study is that the Dutch surveillance network consists of many general hospitals, as well as university hospitals and private medical centers, providing a good reflection of care institutions in the Netherlands. In addition, mandatory standardized postdischarge surveillance methods were used in all of these hospitals. Thanks to the large study population, sound statistical methodology, and the use of standardized definitions for SSIs, we believe that reliable and robust results were achieved.

This study has several limitations. First, despite the broad range of patient- and procedure-related data collected for surveillance, additional factors may contribute to SSI incidence that are not reported for surveillance, such as surgeon expertise and organizational and environmental factors. However, these factors are hospital specific and difficult to measure, and little is known about the actual adherence of individual surgeons to guidelines and work agreements. Second, surveillance data rely on the ability of surveillance personnel to find and report data consistently and correctly.[14] For example, we have become aware that, for breast surgeries without implants, it is very difficult to distinguish deep SSIs from superficial SSIs, and assigning SSIs for this type of surgery to either deep of superficial is, in fact, unreliable. Therefore, currently, the PREZIES network has stopped distinguishing deep from superficial SSIs for this type of surgery. For the interpretation for deep and superficial SSIs, therefore, the analyses excluding breast surgeries are preferable. Third, some heterogeneous surgical procedure types are included in surgical specialties; the risk for SSIs may not be increased for all index surgeries within a specialty. Finally, we are aware that some variables might be interpreted differently by hospital personnel. Although large abnormalities can be identified through the validation of the data, some small errors will always remain. Nevertheless, we assume that a few misinterpretations of the protocol in such a large national surveillance network will not significantly modify the associations we found.

Future Recommendations

Future studies should be conducted to determine the risk differences in developing SSIs considering timing and the type of reoperation. We could not determine whether all types of reoperations and the timing of them are equally important because data regarding the type and reason to perform a repetitive surgery were not available for all specialties. Further investigation is needed to determine whether reporting repetitive surgeries for surveillance purposes can be simplified, or whether reporting is needed for only a selection of surgical procedures. If such a customized system surveillance is possible, SSI surveillance will be more efficient.

In conclusion, we aimed to optimize the current SSI surveillance system in the Netherlands by investigating whether prior, multiple-, and repetitive surgery(-ies) are true risk factors for SSI. Multiple- and repetitive surgeries significantly increased the overall odds of an SSI, whereas a prior surgery did not. Because retrieving information about prior surgeries is time-consuming and laborious, we consider it no longer worthwhile to report this data to the surveillance network, and therefore, we have excluded this variable from the Dutch SSI surveillance protocol. Additionally, we found that reporting multiple surgeries is not required for surveillance if duration of surgery has already been reported. Other national SSI surveillance protocols could also consider removing prior surgery as well as multiple surgeries when duration of surgery is included in the surveillance data.

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SUPPLEMENTARY MATERIAL

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