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Title page

# The Community Burden of Surgical Site Infection Following **Elective** Colorectal Resection

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Original Article

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## **Abstract**

### Aim

Surgical site infection (SSI) is common after colorectal surgery. Recent attempts to measure SSI have focused on in-patient SSI and readmissions. This study examined patient reported SSI at 30 days over 8 years.

### Methods

The Health Protection Agency questionnaire was used to prospectively measure 30-day patient-reported SSI in patients undergoing **elective** colorectal operations between February 2011 and April 2019. Questionnaires were sent by post and followed up with a phone call. Data relating to hospital stay were prospectively recorded on an enhanced recovery (ERAS) database.

### Results

80.7% (**1268**) of **1559** patients responded to the questionnaire with an overall SSI rate of **15.9%** (**201/1268**). The majority of patients who reported SSI presented in the community (**66.7%**) of which 65% consulted their GP and 35% saw a community nurse. Patient reported SSI was validated by a health professional in over 90% of cases. Overall, only 1.5% of readmissions and 2% of ward attendances were due to an isolated wound problem. Patients who developed SSI during their index admission had a longer length of stay (LOS) (11 days vs 4 days) but there was no difference in delayed discharge or complications between patients with and without SSI, suggesting that a previously described association between SSI and increased LOS may be due to observational bias

### Conclusion

Existing surveillance audits are suboptimal for monitoring SSIs following colorectal surgery as most SSIs present after discharge. There is a need for robust 30-day surveillance with a standardised methodology if comparisons are to be made between units.

Statement – What does this paper add to the literature

SSI surveillance audits have focused on in-patients and readmissions. This study demonstrates that 67% of SSI in 1559 patients following elective colorectal surgery presented to community services.

SSI accounts for a low number of delayed discharge, readmission and re-attendance and is not associated with a longer LOS.

## **INTRODUCTION**

Surgical site infection (SSI) is a complex, multifactorial issue with significant implications for both the patient and the health service. It is associated with longer hospital stay, increased rates of intensive care admission, further surgical procedures and mortality (1) and accounts for 14.5% of all hospital-acquired infections (2) and increased cost (3). SSI rates are highest following colorectal surgery (4) and more costly to manage (5).

The standard outcome measure for SSI is development of infection within 30 days of surgery meaning that routinely collected hospital data will not capture SSIs presenting post-discharge. The introduction of **enhanced recovery (ERAS)** protocols have reduced LOS. The median LOS in our hospital is 5 days. As the median time to presentation of SSI is 13 days post-operatively (5), it is likely that previously reported SSI rates have underestimated the true incidence.

There are two nationwide data sources for surgical site infection (6,7), however both demonstrate limitations. Public Health England (PHE) (6) requires mandatory reporting of SSI following orthopaedic, vascular and obstetric surgery but not for gastrointestinal surgery. Their annual report states that only 39% of UK NHS trusts continuously monitor SSI rates for patients undergoing general surgical procedures compared to 61.5% for knee replacements and 80% for CABG (6). Only 19 hospitals presented a complete dataset for lower GI surgery and the reported rate of 8.7% only includes in-patient and readmission data.

The Getting It Right First Time (GIRFT) initiative estimates that English NHS trusts have spent £35.2 million over 5 years on SSI-related medical negligence claims (7). The first GIRFT report for general surgery demonstrated that only 4 out of 50 hospitals were able to report SSI rates (8). There have been two subsequent GIRFT SSI audits, both run over 6 months across multiple specialties with no defined methodology. Data was collected by junior doctors and relied on recording in-hospital SSI and readmissions. This means that trusts with a more robust SSI surveillance programme may

appear to have higher SSI rates than trusts with methods which fail to capture all SSIs. In addition, SSI was attributed to the hospital detecting the SSI, not where it originated and therefore cannot demonstrate an accurate SSI rate per hospital. Only 95 of 198 trusts participated in the first audit. The second audit finished in October 2019 and has not yet reported.

We used the Health Protection Agency questionnaire to measure 30-day patient reported surgical site infection since 2011 (9). This aligns closely with the Centre for Disease Control (CDC) criteria for diagnosis of SSI although the CDC requires confirmation of SSI by a clinician. (10) This was part of a quality improvement project in which implementation of a care bundle in 2013 produced a sustained reduction in SSI from 20% to 10% (11).

The aim of this paper is to describe where and when surgical site infections present, following elective colorectal surgery.

#### **METHOD**

A database was analysed using data collected prospectively for consecutive patients undergoing major elective colorectal surgery (including colorectal resections, abdomino-perineal resection and reversal of Hartmann's) within an ERAS programme at an urban teaching hospital serving a population of 500,000 between Feb 2011 and April 2019. Small bowel resection, surgery involving more than one procedure or ileostomy closure was excluded.

A validated questionnaire from the Health Protection Agency (9) (Figure 1) was sent by post to patients. Patients were sent this questionnaire 1-month post-operatively followed by up to three telephone calls to non-responders. For all patients operated on in a month, the questionnaires would be sent at the end of the subsequent month. If there was no response after 3 months the patient was marked as a non-responder. The questionnaire identifies superficial wound infection by a positive response to one or more of three criteria demonstrated in Table 1. It also asks whether the patient developed a 'wound problem' and whether this developed in hospital. If SSI occurred

post-discharge; patients are asked when symptoms started, which health professional was seen and whether they were readmitted. The questions are not designed to differentiate between superficial and deep infection. As the questionnaire was retrospective, patients received treatment for the SSI at the time of presentation.

Data were entered prospectively onto a database which recorded all aspects of care during the admission and patients were categorised into either wound infection or no wound infection based on questionnaire response.

Patient clinical and demographics are displayed including age, sex, cancer diagnosis, operative approach, presence of stoma and the use of bowel preparation. Uni- and multivariable logistic regression was used to explore the association between SSI and clinical and demographic variables. however, SSI rates over time by surgical procedure in a larger cohort of operations are published elsewhere. (11)

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Data were analysed using Microsoft Excel and Stata version 15.1. Statistical analysis was performed using Chi-squared and Mann-Whitney U test (calculated as two tailed). Mann-Whitney U test was used for the comparison of non-parametric ordinal data.

## **RESULTS**

1572 patients underwent major colorectal operations between 2011 and 2019. 13 patients died within 30 days (0.8%) and were excluded from analysis giving a total of 1559. 1268 patients completed the post-operative questionnaire (81.3% response rate). Median age was 69 years (range 18-94 years) and male: female ratio was 1.14:1. The majority (1446/1559, 92.8%) underwent colorectal resection, 75% for cancer (1162/1559), 69% laparoscopically (1068/1559). Demographic data for respondents and non-respondents were similar except respondents were older and more frequently had cancer

malignancy (table 2). Overall, 15.9% (210/1268) of questionnaire respondents developed a surgical site infection. SSI was associated with open surgery, surgery for benign conditions and the presence of a stoma but was unrelated to type of bowel preparation (phosphate enema vs mechanical bowel preparation without oral antibiotics) in left sided procedures (table 3).

66.7% of patients with SSI (134/201) presented in the community, of which 65% (87/134) consulted their GP and 35% (47/134) a community nurse.

#### **Readmission and Reattendance**

There are 2 data sources for readmission and re attendance-the prospectively recorded data on the database completed for all ERAS patients and the questionnaires filled in by patients.

Overall, there was a 10% readmission rate (160/1559), of which 24 were due to a wound problem. 7% (111 / 1559) of patients attended the ward following discharge from hospital, 32 due to a wound problem. This gives an overall rate of 1.5% of readmissions and 2% of ward attendances due to a wound problem alone.

When evaluating the questionnaire data, of patients with patient reported SSI, 17% (35/201) of patients with SSI were readmitted. Twelve of these patients were readmitted because of a wound problem. Twenty-three (14%) of the SSI patients had a ward attendance following discharge, and 16 of these attended the ward due to a problems with their wound. This results in a 6% readmission rate and 8% re-attendance rate due to the wound problem, for patients with SSI.

In response to the questionnaire, two patients said they were not readmitted with a wound infection but correlation with clinical records contradicted this. In addition, 35 patients stated that they were readmitted due to a wound infection but only 29 continued to answer the rest of the questionnaire to confirm SSI.



### Timing of SSI

182 patients of 201 patients provided the date of symptom onset. Four patients stated 603, 104, 74 and 67 days to infection which appeared to be due to date error and have been excluded leaving 178 patients. The median time from operation to symptoms was 11 days (range 1-57). Most SSI symptoms presented by day 15 (124/178, 70%). Only 20.8% (37/178) had symptoms by day 5. (Figure 2) 130/178 patients (73%) reported onset of symptoms post-discharge, compared to 48/178 (27%) who had onset of symptoms in hospital (this includes 8 who stated symptoms started on day of discharge).

SSI was defined as meeting at least one of the three criteria (table 1). 48% of patients (96/201) fulfilled one criterion, whilst 28% (57/201) fulfilled two criteria and 24% (48/201) met all three criteria. Of those identifying with just one criterion, 82% (79/96) identified with criteria 1 or 3 which are the two criteria for which patients are prescribed antibiotics, which by necessity means that a health professional must have assessed and diagnosed an SSI. In total, 92% of patients fulfilled criteria 1 and 3. This also aligns with the CDC criteria for diagnosis of SSI. (10) Therefore, only 8% (17/201) of patients had an SSI diagnosed on patient-reported symptoms alone.

178 patients recorded an accurate date of onset for SSI symptoms. Patients who developed symptoms prior to discharge had a significantly longer median LOS compared to those who developed symptoms after discharge (11 days vs. 4.5 days, range 3-232 and 0-21 respectively;  $P < 0.0001$  Mann Whitney U test)

In the ERAS database, it is recorded whether a patient was considered to have a discharge date delayed beyond their expected LOS, along with the primary reason for the delay. There was no statistically significant difference in the proportion of patients experiencing a delayed discharge in the SSI compared to the non-SSI group (54.7% (110/201) vs 51% (545/1067),  $\chi^2 = 0.90$ ,  $p = 0.34$ ). In

only two cases was SSI documented as being the reason for the delay. There was no statistically significant difference in SSI rate observed between those patients recorded as a delayed discharge (110/655, 16.8%) compared to those without a delay (86/589, 14.6%;  $P=0.29$ ). There was no difference in concurrent post-operative complications between the SSI and non-SSI groups; 38% (77/201) compared to 36% (385/1067) ( $\chi^2=0.36$ ,  $p=.55$ ).

There was no difference in return to theatre rates during the index admission, 5.4% for those with SSI (11/201) vs 4% without SSI ( $n=45/1067$ ) ( $\chi^2 0.6313$ ,  $p=0.43$ ) or on readmission, 3.5% for those with SSI (7/201) vs 1.6% without SSI (17/1067) ( $\chi^2=3.25$ ,  $p=0.07$ ).

## **DISCUSSION**

This study is the largest UK series examining the burden of SSI after colorectal surgery across the healthcare system. Overall, 15.9% of questionnaire respondents reported SSI (210/1268). The main finding of this paper is that 66.7% of patients with SSI presented to community services. This means that any data collection strategy which focuses on in-hospital SSI surveillance and readmission such as GIRFT will grossly under report SSI.

PHE has demonstrated that large bowel surgery shows the greatest variability of in-patient and readmission SSI rates from 0.3% to 24.9% (12) and the highest in-patient SSI rate, at 8.7%. If looking only at SSI presenting in hospital or on readmission/ward attendance, our SSI rate would be 9.4% (119/1268), which is comparable to previous studies. GIRFT did not include colorectal resection as a separate group but reported a SSI rate of 18.8% for emergency laparotomy detected only by in-hospital surveillance and readmission (7).

The more robustly SSI is measured, the higher the SSI rate. The ROSSINI trial reported SSI following emergency and elective laparotomy to assess use of wound protectors (13). 61/237 patients in the wound protector group and 58/111 controls underwent colorectal surgery with no difference in SSI rate between using (24.7%) or not using (25.4%) a wound protector. Patients with SSI had 8.03

interactions with community healthcare professionals compared to 3.26 in those without SSI. The Bluebelle study used a validated questionnaire to identify SSI followed by a face-to-face follow up (14) and reported a rate of 18.1% in patients having abdominal surgery. **An intensive 30-day post-operative surveillance programme in Spain in 13,000 patients found an SSI rate of 20.7%. (15)** This demonstrates that although the 20% SSI rate reported in this study prior to the introduction of a care bundle (11) may appear high, it is comparable, if not better, than studies which used post discharge surveillance to monitor SSI up to 30 days.

There have been previous attempts to identify where and when SSIs present. A systematic review by Woelber et al of SSI following all types of surgery included 55 studies over 2 decades (1995-2015). (16) Follow-up varied between telephone calls, patient questionnaires and outpatient appointments. There were 12 colorectal studies included with an overall SSI rate of 12% and post discharge presentation of between 37-56%. The studies were heterogeneous with no standardised definition of SSI and variable follow-up but they do suggest a large proportion present after discharge. **A Scandinavian study of 114 patients undergoing colorectal surgery found a 50% increase in SSI rate once patients were followed up after discharge, from 5.8% to 8.9%. (17)**

There are very few UK studies of SSI following colorectal surgery. A prospective study of 388 patients undergoing general and vascular surgery in 2016, reviewed patients in hospital and used a telephone questionnaire at 30-days (18). This showed an SSI rate of 16.2%, with 57% presenting post-discharge. Tanner et al studied 105 patients in 2009 undergoing colorectal surgery for 30-days with telephone interviews and home visits, finding that 27% (29/105) of patients developed SSI, with 41% occurring post-discharge. (5) The only study that used the HPA questionnaire was a small study of 122 colorectal patients from Howard et al (19) in 2010 who demonstrated an SSI rate of 19% (7% in laparoscopic and 25.3% after open surgery) with 58% of SSI presenting post-discharge.

The widespread adoption of ERAS protocols and laparoscopic surgery is likely to have impacted on the community burden of SSI as a higher proportion of patients now present in the community.

### **Length of stay and readmission**

Patients with SSI presenting on their index admission had a median LOS of 11 days compared to 4.5 days in whom SSI presented after discharge. Previous data have suggested that SSI is associated with longer LOS (20), with many implying causation. Our study casts doubt on this, as the majority of SSIs in our cohort presented after discharge, presenting a median of 11 days post-operatively. There was no difference in the median LOS between SSI and non-SSI groups. For patients where SSI was diagnosed on the index admission the median LOS was higher but in only 2 cases was SSI documented as the primary reason for delayed discharge, with the remainder staying in hospital due to another complication. This suggests that in previous studies where in-patient SSI has been examined, patients who had a longer LOS because of another concurrent complication were more likely to have their SSI detected, simply as a function of being an inpatient at the time of symptom onset. This may have appeared as an association between SSI and longer LOS when in fact SSIs presenting after discharge were not detected.

This was also an observation in the ROSSINI trial that there was a higher than expected infection rate in clean and clean-contaminated operations (13). The combined infection rate for clean and clean-contaminated patients at the wound review on day five to seven was only 6.5% compared with 12.1% at this stage for the contaminated and dirty wounds. However, these more minor, and often elective, operations tended to have a shorter length of hospital stay and so most SSI in these patients were diagnosed after discharge suggesting that the apparently lower infection rates in this group of patients reported elsewhere could represent observational bias.

A Canadian study of 2876 patients undergoing colorectal surgery in an ERAS protocol (21) showed that 11.6% of patients re-attended ED of which 34.5% were due to SSI, and 8.2% were readmitted, 11.5% for SSI. Our readmission rate was comparable, at 10% with 15% due to SSI. In our centre, post-operative ED presentations are diverted to a ward-based "hot clinic", occurring in 7% of

patients, with 28% due to SSI. In the majority of cases readmission was for another problem rather than SSI, suggesting that although SSI is common, the burden on hospital services is relatively small.

#### **Strengths and Limitations of Patient Reported Outcomes**

This study has several limitations. Patient reported outcomes (PROMs) by their nature carry a risk of over-reporting complications. ~~There is a risk of volunteer bias as patients with a wound problem might be more likely to respond to the questionnaire. Respondents and non-respondents were generally well matched. However, there were slightly fewer respondents with benign disease and/or a stoma yet both of these factors increased the likelihood of SSI suggesting that volunteer bias was less likely.~~ And tThere may also be recall bias when completing a questionnaire or patients might misunderstand the question or might interpret a normal healing wound as infected. ~~We report elsewhere that after testing alternative methods of measuring SSI, paper questionnaire plus telephone follow-up to non-respondents was the most reliable. (11)~~ However, there were 4 incidents where patients gave their onset of symptoms beyond 60 days. It appeared that they had written the wrong year or month. There were also 6 patients who were readmitted with a SSI but who did not go on to fully complete the SSI questionnaire (presumably assuming we already had the information) which meant the SSI was not confirmed using the patient reported outcome methodology. Two patients were readmitted with a wound problem when they said ~~in the questionnaire that~~ they were not. We have presented the patient reported data accurately and ~~have to~~ accept that there are limitations to using patient reported data for re-attendance and readmission. However, we have also shown that most data for presence of SSI is not 'patient reported' as 93% of ~~respondents with SSI~~ were prescribed antibiotics by a healthcare professional, ~~who confirmed the SSI diagnosis. This also makes recall bias less likely as patients are unlikely to misremember seeing a healthcare professional in the recovery phase after a resection.~~

A strength of this study is that the questionnaire response rate was excellent at 81.3% using a combined approach of postal and telephone follow-up. Although it is a single centre study, it is the largest series of SSI after colorectal resection in the UK and the SSI rates align with other research studies where SSI rates have been measured with robust follow-up. (13-15)

Improving accuracy of PROMs for SSI surveillance might include better patient education or post-operative wound photography (22) where a healthcare professional performs a wound review without the need for GP or hospital attendance (23).

Patient-recorded outcomes are time consuming and costly to implement in terms of sending questionnaires and uploading and interpreting data. For specialties where there is a very high rate of readmission when SSI occurs (for example cardiac surgery), SSI rates calculated from hospital data are largely reliable, however we have demonstrated that this is not the case for colorectal patients. If GIRFT methodology is followed ie SSI presenting in-hospital and on readmission, SSI will be significantly under reported as 50.1% presented to the community alone (102/201 SSI patients only saw a community professional with no readmission or post-discharge ward attendance). The trade-off is that by using patient reported outcomes, a small proportion (12 patients) might be inaccurate as described above and SSI is likely to be under reported for patients who remain in hospital beyond 30 days as we did not use in-hospital surveillance. A potential solution would be data linkage between community services (e.g. GP practices) and hospitals, which would enable easy capture of data when patients present to either service with SSIs. This is currently being developed for our group of patients.

## **CONCLUSION**

This is a comprehensive study of where and when SSI presents after colorectal surgery in England. The majority of SSIs present to the community and they account for a low number of delayed discharge, readmissions and ward attendances. In contrast to previous studies, the longer LOS associated with SSI appears not due to the SSI itself but is due to SSI not being detected in patients who have a short LOS as their SSI will present after discharge. Measurement of SSI is difficult but we have demonstrated that 'patient reported' SSI for colorectal surgery is supported by a health professional in over 90% of cases. Existing surveillance audits are suboptimal for monitoring SSIs following colorectal surgery due to the significant proportion of SSIs presenting after discharge. There is a need for robust 30-day surveillance with a standardised methodology if comparisons are to be made between units.

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**Figure 1: Patient questionnaire**

Have you had any problems with the healing of your wound?  
 Yes  Please continue with this questionnaire  
 No  You do not need to continue with any further questions.

Did the problems with your wound arise when you were in hospital?  
 Yes   
 No

Since you were discharged from hospital after your operation have you noticed any of the following symptoms?  
 Has there been any discharge or leakage of fluid from any part of the wound?  
 Yes   
 No   
 If yes, was it either: Clear or blood stained   
 Yellow/green (pus)   
 Other – please specify \_\_\_\_\_

Please tick any of the following additional symptoms that applied to your wound:  
 Pain or soreness in addition to the discomfort experience following the operation  
 Redness or inflammation spreading from the edges of the wound  
 The area around the wound felt warmer/hotter than the surrounding skin  
 The area around the wound became swollen  
 The edges of any part of the wound separated or gaped open

Did any health care worker take a sample from your wound to send to the laboratory?  
 Yes   
 No

If you saw a health care worker because of these symptoms, please indicate who you saw from the list below  
 –  
 GP   
 District Nurse   
 Midwife   
 Doctor or Nurse at the hospital   
 Other – please specify   
 Did not see anyone about my wound

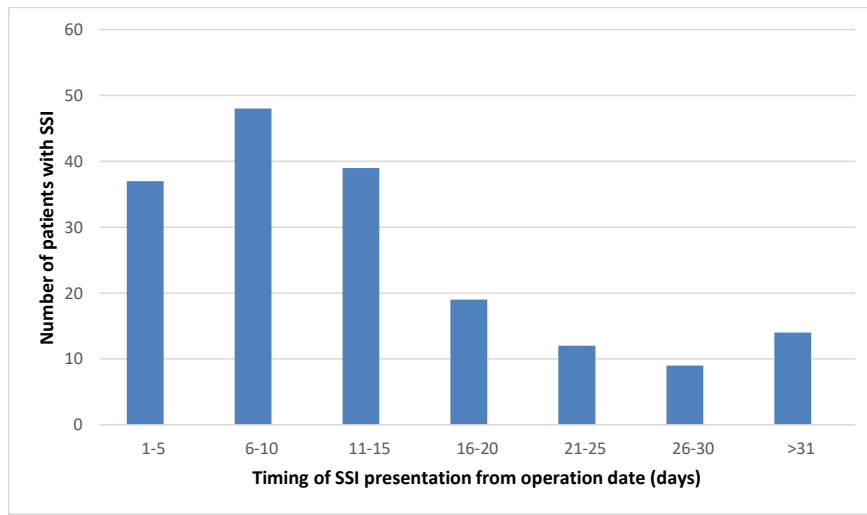
Please tell us the date you noticed these symptoms.  
 If you can not remember the exact date, please give an approximate date \_\_\_/\_\_\_/\_\_\_

Have you been prescribed antibiotics for an infection in the wound?  
 Yes   
 No   
 If yes, who prescribed them? \_\_\_\_\_

Have you been readmitted to hospital with an infection of the surgical wound?  
 Yes   
 No   
 If yes, which hospital? \_\_\_\_\_

Other comments  
 \_\_\_\_\_

**Figure 2: Timing of SSI symptoms from date of operation**





*Table 1: Summary of the key features for three infection criteria*

<u>CRITERIA 1</u>	<u>CRITERIA 2</u>	<u>CRITERIA 3</u>
<p>Discharge or leakage of fluid from any part of the wound</p> <p>AND antibiotics prescribed for a wound infection</p>	<p>Edges of any part of the wound separated or gaped open</p> <p>AND at least 2 clinical signs:</p> <ul style="list-style-type: none"> <li>- Pain or soreness in addition to discomfort following the operation</li> <li>- Redness or inflammation spreading from edges of the wound</li> <li>- Area around the wound felt warmer/hotter than surrounding skin</li> <li>- Area around the wound became swollen</li> </ul>	<p>Antibiotics have been prescribed</p> <p>AND at least 2 clinical signs:</p> <ul style="list-style-type: none"> <li>- Pain or soreness in addition to discomfort following the operation</li> <li>- Redness or inflammation spreading from edges of wound</li> <li>- Area around wound felt warm/hotter than surrounding skin</li> <li>- Area around wound became swollen</li> </ul>

*Table 2: Demographics of overall cohort, cohort who completed the questionnaire and cohort who reported SSI and univariate analysis of demographic and surgical characteristics for those with and without an SSI*

<b>Patient characteristic</b>	<b>Total patients</b>	<b>Questionnaire Responders</b>	<b>Questionnaire Non - responders</b>	<b>No SSI patients</b>	<b>SSI patients</b>
<b>Total n</b>	1559	1268	291	1067	201
<b>Age, years median (range)</b>	69 (18-94)	69 (18-93)	66 (18-94)	67 (18-93)	65 (21-91)
<b>Female n (%)</b>	729 (47)	578 (46)	151 (52)	485 (45)	93 (46)
<b>Diagnosis n (%)</b>					
Malignancy	1162 (74.5)	968 (76.4)	194 (66.7)	835 (78.3)	133 (66.2)
No malignancy	381 (24.5)	287 (22.6)	94 (32.3)	221 (20.7)	66 (32.8)
Unknown	16 (1.0)	13 (1.0)	3 (1.0)	11 (1.0)	2 (1.0)
<b>Stoma n (%)</b>					
Yes	606 (38.9)	483 (38.1)	123 (42.3)	389 (36.5)	94 (46.8)
No	932 (59.8)	770 (60.7)	162 (55.7)	663 (62.1)	105 (52.2)
Unknown	21 (1.3)	15 (1.2)	6 (2)	15 (1.4)	2 (1.0)
<b>Bowel preparation n (%)</b>					
Full bowel prep	300 (19.2)	248 (19.5)	52 (17.9)	209 (19.6)	39 (19.4)
Phosphate enema	713 (45.7)	583 (46)	130 (44.7)	483 (45.3)	100 (49.7)
No bowel prep	523 (33.6)	418 (33.0)	105 (36)	360 (33.7)	58 (28.9)

Unknown	23 (1.5)	19 (1.5)	4 (1.4)	15 (1.4)	4 (2.0)
<b>Operation type</b>					
n (%)					
Resection	1446 (92.8)	1180 (93)	266 (91.4)	999 (93.6)	181 (90.0)
Hartmanns reversal	100 (6.4)	78 (6.2)	22 (7.6)	59 (5.5)	19 (9.5)
Defunctioning Stoma formation	13 (0.8)	10 (0.8)	3 (1.0)	9 (0.9)	1 (0.5)
<b>Approach n (%)</b>					
Open	333 (21.4)	275 (21.7)	58 (19.9)	214 (20.0)	61 (30.3)
Laparoscopic	1068 (68.5)	864 (68.1)	204 (70.1)	746 (70.0)	118 (58.7)
Lap converted	125 (8.0)	100 (7.9)	25 (8.6)	85 (8.0)	15 (7.5)
Unknown	33 (2.1)	29 (2.3)	4 (1.4)	22 (2.0)	7 (3.5)

Table 3 Uni- and multivariable analysis exploring the correlation between SSI and clinical and demographic characteristics in questionnaire responders (n=1,268)

	<u>Univariable</u>			<u>Multivariable</u>		
	<u>OR</u>	<u>95% CI</u>	<u>P value</u>	<u>OR</u>	<u>95% CI</u>	<u>P value</u>
<b><u>Female</u></b>	<u>1</u>	<u>(0.8 to 1.4)</u>	<u>0.83</u>	<u>1</u>	<u>(0.7 to 1.4)</u>	<u>0.99</u>
<b><u>Cancer diagnosis</u></b>	<u>0.5</u>	<u>(0.4 to 0.7)</u>	<u>&lt;0.01</u>	<u>0.7</u>	<u>(0.5 to 1.0)</u>	<u>0.04</u>
<b><u>Stoma formation</u></b>	<u>1.5</u>	<u>(1.1 to 2.1)</u>	<u>0.01</u>	<u>1.3</u>	<u>(0.9 to 1.8)</u>	<u>0.19</u>
<b><u>Bowel Prep*</u></b>						
<u>Full Prep</u>	<u>1.2</u>	<u>(0.7 to 1.8)</u>	<u>0.51</u>	<u>0.9</u>	<u>(0.6 to 1.5)</u>	<u>0.77</u>
<u>Enema</u>	<u>1.3</u>	<u>(0.9 to 1.8)</u>	<u>0.16</u>	<u>1</u>	<u>(0.7 to 1.5)</u>	<u>0.99</u>
<b><u>Approach‡</u></b>						
<u>Laparoscopic</u>	<u>0.5</u>	<u>(0.4 to 0.8)</u>	<u>&lt;0.01</u>	<u>0.7</u>	<u>(0.4 to 1.0)</u>	<u>0.03</u>
<u>Laparoscopic - assisted</u>	<u>0.9</u>	<u>(0.4 to 2.3)</u>	<u>0.9</u>	<u>1.1</u>	<u>(0.5 to 2.8)</u>	<u>0.77</u>
<u>Laparoscopic - converted</u>	<u>0.6</u>	<u>(0.3 to 1.1)</u>	<u>0.13</u>	<u>0.7</u>	<u>(0.4 to 1.4)</u>	<u>0.36</u>
<b><u>Age per year</u></b>	<u>0.98</u>	<u>(0.97 to 0.99)</u>	<u>&lt;0.01</u>	<u>1</u>	<u>(1.0 to 1.0)</u>	<u>&lt;0.01</u>

\* Reference group received no bowel preparation

‡ Reference group received open surgery

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