Public Health England

Protecting and improving the nation's health

Surveillance of surgical site infections in NHS hospitals in England, 2017 to 2018

December 2018

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Key points

In 2017/18, 201 NHS hospitals representing 142 NHS trusts and 8 Independent Sector (IS) NHS treatment centres participated in PHE surgical site infection (SSI) surveillance.

Surveillance data were submitted for 134,119 procedures, 105,771 as part of mandatory orthopaedic surveillance and 28,348 spanning 13 other voluntary surveillance categories.

In 2017/18 the majority of hospitals participating in mandatory surveillance of hip and knee replacement surgery carried out continuous surveillance (60.2% and 59.9%, respectively).

The highest levels of continuous surveillance were seen for cardiac (non-CABG) surgery at 80%.

Cumulative incidence of inpatient and readmission-detected SSI ranged from 8.7% for large bowel surgery to <1.0% for hip and knee replacement surgery (April 2013 to March 2018).

Trends in annual SSI incidence from 2009/10 to 2017/18 varied by surgical category with hip and knee replacement surgery decreasing further from 0.6% and 0.5% in 2016/17 to 0.5% and 0.4% in 2017/18, respectively.

Large and small bowel surgery showed an increase in SSI incidence in 2017/18, reaching 8.5% and 6.5%, after recent downward trends between 2014/15 to 2016/17.

Large bowel surgery showed the greatest variability in SSI risk between hospitals, ranging from 1.6% to 20.7% (April 2013 to March 2018); hip and knee replacement surgery show the least variation (0.0% to 2.9% and 0.0% to 2.8% respectively).

In 2017/18, 3 NHS trusts were identified as statistical high outliers for SSI following orthopaedic surgery (SSI risk higher than the annual SSI incidence 10 years ago); 1 trust was a statistical low outlier for SSI for both hip replacement and repair of neck of femur.

Of the 1,338 SSIs reported in 2017/18, the highest proportion classified as superficial incisional was for small bowel surgery (57.8%); the highest proportion classified as deep incisional or organ space were for cranial surgery (85%).

Enterobacteriaceae made up the largest proportion of causative organisms in 2017/18 across all surgical categories (30.8%), accounting for between 11.1% (knee replacement) to 53% (large bowel surgery) of SSIs.

Between 2016/17 to 2017/18, the greatest relative increase in the proportion of causative SSI organisms was for coagulase-negative staphylococci (16%), while Enterobacteriaceae increased by 8%.

Contents

Surgical Site Infection (SSI) Surveillance Service

Introduction

This report summarises the data submitted by NHS hospitals and independent sector (IS) NHS treatment centres in England to the national SSI Surveillance Service (SSISS) at Public Health England (PHE). The aim of the national surveillance program is to enhance the quality of patient care by encouraging hospitals to use data obtained from surveillance to compare their rates of SSI over time and against a national benchmark, and to use this information to review and guide clinical practice. The SSISS provides an infrastructure for hospitals to collect data on 17 surgical categories spanning general surgery, cardiothoracic, neurosurgery, gynaecology, vascular, gastroenterology, and orthopaedics.

The SSISS was established by the Public Health Laboratory Service (a predecessor of PHE) in 1997. From April 2004, NHS trusts performing orthopaedic surgery have been mandated by the Department of Health to carry out surveillance for a minimum of 3 consecutive months per financial year in at least 1 of 4 orthopaedic categories: hip replacement, knee replacement, repair of neck of femur or reduction of long bone fracture [1]. NHS hospital participation in other categories remains voluntary.

This report includes surveillance data submitted to SSISS based on surgery which took place from 1 April 2004 to 31 March 2018, with a focus on the latest financial year (2017/18).

Methods

SSISS data collection

PHE has produced a surveillance protocol outlining the case definitions and case finding methods which all participating hospitals must adhere to [2]. To maintain the quality of surveillance data, hospitals participating in PHE's national SSI surveillance programme are required to have staff attend a one-day training course at the PHE national co-ordinating centre in London before carrying out surveillance. Surveillance data are collected prospectively on a quarterly basis and include all eligible patients undergoing surgery in pre-selected surgical categories during each 3 month period. Patients are followed-up to identify SSIs for 30 days after surgery for non-implant procedures and for 1 year for procedures involving a prosthetic implant. A set of demographic and surgery-related data are collected for each eligible procedure and submitted to the PHE SSISS via a secure web-based application.

After each completed quarter, data are subject to quality assurance processes by the PHE SSISS to identify anomalies or missing data. Participating hospitals can download automated confidential reports securely from the SSISS web application for dissemination within their trust. These reports provide hospitals' crude and risk-stratified SSI incidence and the corresponding national benchmark by surgical category.

As part of ongoing support to help hospitals monitor SSI risk, the PHE SSISS team analyse submitted data at quarterly intervals to identify 'outliers', defined as hospitals whose SSI risk is above the national 90th percentile ('high outliers') or below the 10th percentile ('low outliers') for each surgical category. PHE alerts these hospitals of their outlier status and encourages them to investigate possible reasons. Hospitals identified as 'low outliers' are asked to investigate their case ascertainment methods, to ensure all cases are being reported, while hospitals identified as 'high outliers' are asked to explore their clinical practices and discuss their results at multidisciplinary team meetings so that possible reasons can be explored and potential problems addressed at the earliest opportunity. PHE offers support to outlier hospitals to assist them with further investigations, including PHE on-site visits to share in-depth local analyses and further surveillance advice.

Case finding

Active surveillance is undertaken by hospital surveillance staff to identify patients with SSIs during their initial inpatient stay. Hospitals are also required to have systems in place to identify patients subsequently readmitted to hospital with an SSI. SSIs identified on readmission are assigned to the hospital where the original operation took place. Other post-discharge surveillance methods are recommended, especially for short-stay procedures, but remain optional. They comprise: a) systematic review of patients attending outpatient clinics or seen at home by clinical staff trained to apply the case definitions and b) wound healing questionnaires completed by patients 30 days after their operation [2]. Data derived from these optional methods are not currently included in the national benchmarks or used for outlier assessment but provide a sensitive measure of an individual hospital's infection risk to inform local assessment of trends.

Case definitions

The PHE SSISS protocol defines SSIs according to standard clinical criteria for infections that affect the superficial tissues (skin and subcutaneous layer) of the incision and those that affect the deeper tissues (deep incisional or organ-space). These are based on the definitions established by the US Centers for Disease Control and Prevention (CDC) [3] with a minor modification, involving the requirement for pus cells in addition to a positive culture from wound samples (for all SSI types) and the need for at least 2 symptoms to accompany a clinical diagnosis (superficial SSIs only).

Participation in international surveillance

PHE shares anonymised SSI surveillance data with the European Centre for Disease Prevention and Control (ECDC) HAI-Net on an annual basis using ECDC's protocol, also based on CDC definitions [4]. As data are anonymised, they cannot be traced back to individual patients, surgeons or hospitals. All published results are aggregated at the country level. ECDC collates SSI data from other European member states and publishes comparative analyses including trends. These provide an opportunity to examine variation in the SSI incidence between European countries and to improve understanding of how these infections may be prevented. Inter-country variation can however be due to differences in surveillance methodology and/or risk factors [5].

Analyses presented in this report

Surveillance data for surgical procedures between 1st April 2004 and 31st March 2018 were extracted on 15 November 2018 for this report. The SSIs included in this report are based on cases detected during the inpatient stay or on readmission to hospital. For benchmarking purposes, cumulative five-year data were used (April 2013 to March 2018). Where there were low numbers of observations to calculate results, pooled five-year data were used and/or analyses was restricted to higher volume categories.

The SSI risk described in this report is presented as a cumulative incidence [= (number of SSIs/number of procedures) x 100]. Incidence density was calculated to account for differences in the length of follow-up in hospital. Incidence density, based on inpatient-detected SSI cases, is presented as number of SSIs per 1,000 inpatient days of follow-up [= (number of inpatient SSIs/number of days of follow-up) x 1000]. Where applicable, 95% confidence intervals have been provided for results. Confidence intervals were calculated using normal approximation intervals. As measures represent proportions, a binomial distribution was assumed.

Funnel plots were produced to compare SSI incidence across NHS trusts for the most recent financial year for the mandatory orthopaedic categories. Each plot identifies trusts that fall within the expected variation and those that are outliers (SSI incidence falling above or below the 95% confidence limits). IS NHS treatment centres are included in these plots. An additional supplement to this report contains the 2017/18 SSI incidence by NHS trust or treatment centre:

www.gov.uk/government/publications/surgical-site-infections-ssi-surveillance-nhs-hospitals-in-england

SSISS overview

Hospital participation and surgical volumes

Overall, 201 NHS hospitals representing 142 NHS trusts and an additional 8 IS NHS treatment centres participated in the SSISS in 2017/18. Surveillance data were submitted for 134,119 procedures. Of these, 105,771 were orthopaedic procedures submitted as part of mandatory surveillance and 28,348 voluntary surveillance spanning 13 other surgical categories. Compared to 2016/17, there was a slight (2%) decrease in the number of procedures submitted for the mandatory surveillance categories. The number of hospitals submitting mandatory surveillance however, has remained relatively consistent (195 in 2016/17 and 198 in 2017/18). In 2017/18, there was a decrease in the number of procedures (5%) and number of hospitals (16%) submitting data for the voluntary surveillance categories compared to 2016/17. Highest participation was for the mandatory surveillance of hip and knee replacement surgery (166 and 157 participating hospitals in 2017/18, respectively). Of note, when comparing 2017/18 hospital participation numbers by surgical category to 2016/17, there were 7 fewer hospitals participating in large bowel surgery surveillance and 7 more hospitals participating in repair of neck of femur surgery surveillance.

Figure 1: Annual participation in the SSISS, voluntary and mandatory surveillance, NHS hospitals England, April 2004 to March 2018

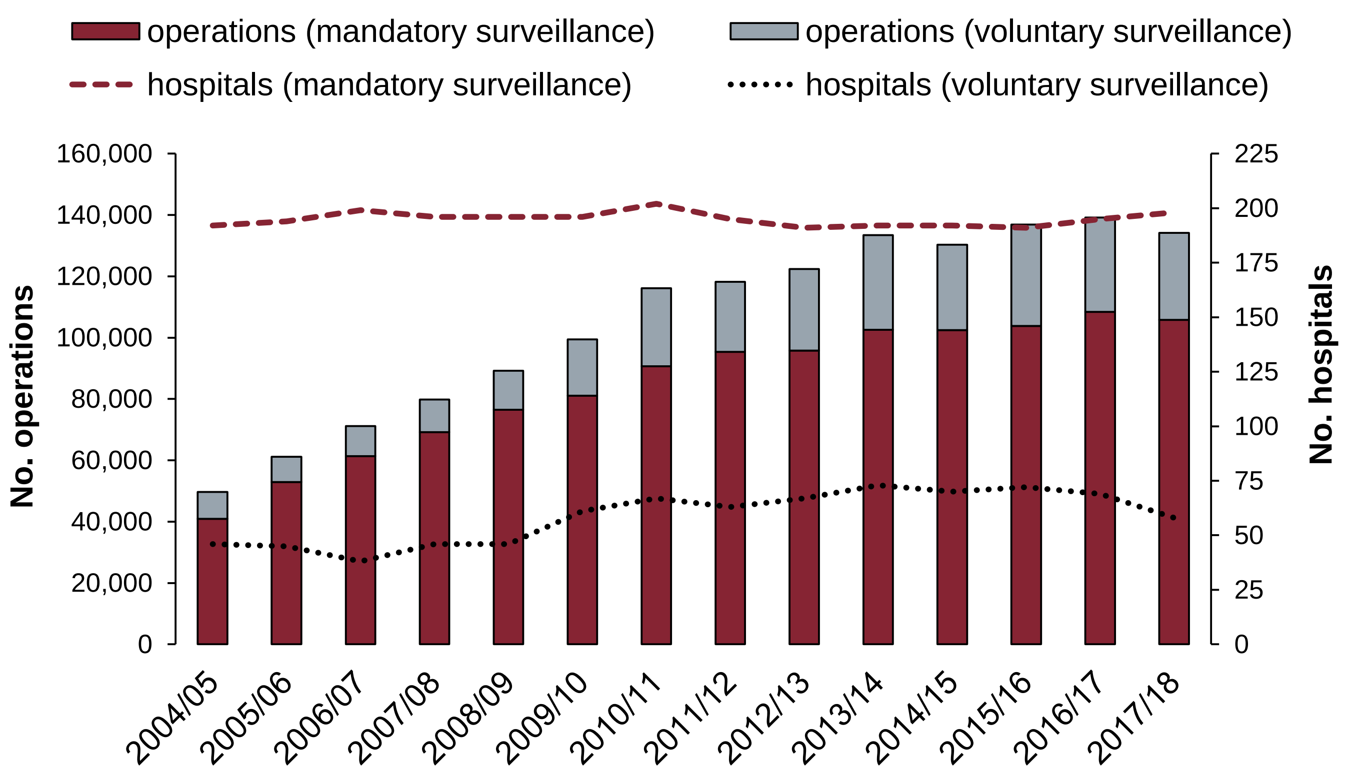
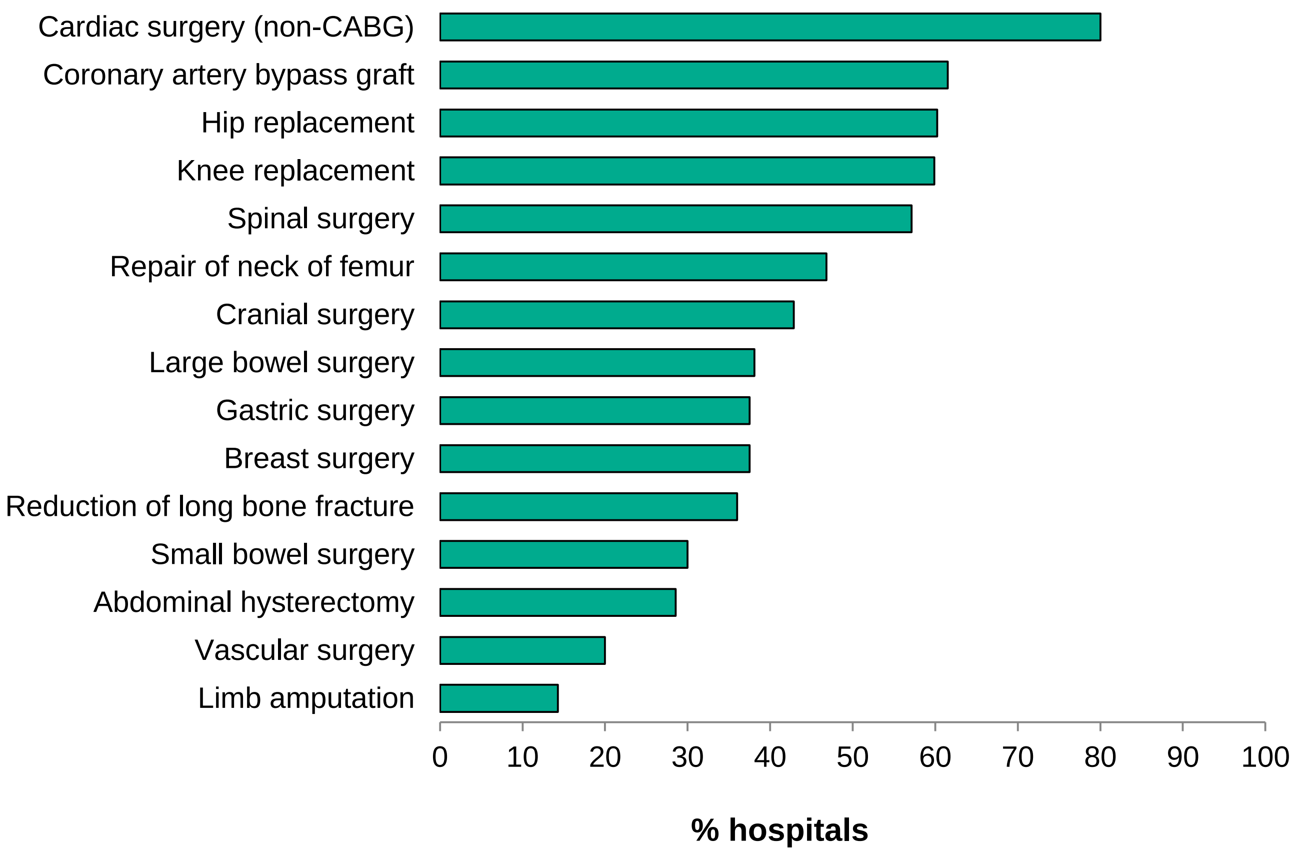


Figure 2 shows the proportion of hospitals carrying out continuous surveillance during 2017/18 by surgical category. Two SSISS surgical categories with <5 participating hospitals (cholecystectomy and bile duct, liver or pancreatic surgery) were excluded.

Cardiac surgery categories (both coronary artery bypass graft [CABG] and non-CABG) had the highest proportion of hospitals carrying out continuous surveillance (8 of 13 participating hospitals and 8 of 10 participating hospitals) throughout the most recent financial year (2017/18). For the mandatory hip and knee replacement categories, more than half of hospitals submitted data for all 4 quarters (60.2% and 59.9%, respectively). These percentages remain comparable to those reported in 2016/17 for continuous surveillance (both 62%).

Figure 2: Proportion of hospitals undertaking continuous surveillance, by surgical category, NHS hospitals England, April 2017 to March 2018



Patient and surgery-related characteristics

The SSISS collects surveillance data for a number of key patient and surgery-related characteristics for each submitted procedure. Data completion for these characteristics is important to help hospitals better understand their results according to potential risk factors. This is particularly helpful for hospitals whose SSI risk is significantly higher than the national benchmark as a means to identify what might be contributing to this increased risk. As a result, the majority of these data elements are mandated for collection as per the SSISS protocol, meaning that a response must be provided for data submission. However, for a number of fields “unknown” or “missing” is an available response option (see *Appendix A* for more details).

Table 1 shows the percentage of all submitted records for 2017/18 with complete information for key patient and surgical characteristics, meaning that a valid response has been provided. Data completeness remains high (≥95%) for most required data elements. Where an “unknown” response option is available we see some variation, particularly in the American Society of Anaesthesiologists’ (ASA) score which ranges from 58% for limp amputation to 100% for cholecystectomy. ASA score is 1 of the 3 risk factors used in scoring a patient’s overall NHSN risk index (see glossary), which allows hospitals to examine risk-stratified SSI incidence results. The proportion of records with body mass index (BMI) information, which is calculated using optional height and weight data fields, is 41%. In 2017/18, the number of surgical categories with BMI data for ≥50% of submitted procedures increased from 8 (2016/17) to 12. CABG had the highest BMI completion rate (92.2% in 2017/18) and limb amputation had the lowest (18.2% in 2017/18). An elevated BMI has been shown to increase the likelihood of developing an SSI, particularly among patients undergoing cardiac surgery [6; 7]. As a known risk factor, completing BMI information is important for hospitals to improve interpretation of SSI risk.

Based on data available for 2017/18, Table 2 shows the distribution of key patient and surgical characteristics. Results for surgical categories with <5 participating hospitals should be interpreted with caution. The median age varied by surgical category, and remained highest for repair of neck of femur procedures (85 years) and lowest for abdominal hysterectomy (54 years). Categories with the highest proportion of paediatric (<18 years of age) data submitted were spinal surgery (13% of all procedures) and cardiac (non-CABG) surgery (10% of all procedures). The cardiac surgical categories (both CABG and non-CABG) had the highest proportion of patients with an ASA score ≥3 (both >90%), followed by patients undergoing limb amputation (87.3%). As in 2016/17, small bowel surgery, limb amputation and large bowel surgery had the highest proportion of procedures with a wound classified as contaminated or dirty (48.6%, 24.7% and 18.4%, respectively). Among categories with BMI data completion rates of 50% or more, knee replacement surgery and gastric surgery had the highest proportion of patients (55.5% and 42.9%, respectively) classed as obese (BMI ≥ 30kg/m^2). In 2016/17 we saw a similar proportion of obese patients reported for these categories (55.8% and 33.7%). Compared to 2016/17 the proportion of obese patients undergoing surgery in 2017/18 remained relatively similar (within 5%) for the majority of surgical categories (12 of 17). The proportion of patients undergoing vascular surgery classified as obese in 2017/18 increased 6% compared to 2016/17. The proportion of operations performed on an emergency basis (defined as procedures that are immediate, unplanned and life-saving or those that are performed immediately after resuscitation) was highest for cranial surgery (7.8%) and large bowel surgery (6.5%).

For patients undergoing hip and knee replacement, information is collected on primary indication for surgery. Figures 3a-b show that osteoarthritis remains the primary indication for the majority of these procedures carried out in 2017/18 (81.8% and 91.7%, respectively). The second most common indication was revision due to any reason (9.5% and 6%, respectively).

Table 1: Data completeness for patient and surgery-related characteristics by surgical category, NHS hospitals England, April 2017 to March 2018

			Patient-related characteristics				Surgery-related characteristics						
Surgical category	No. participating hospitals	No. operations	Age (%)	Sex (%)	BMI† (%)	ASA score (%)	Wound class (%)	Operation duration (%)	Pre-op stay (%)	Elective surgery (%)	Trauma surgery† (%)	Primary indication† (%)	Antibiotic prophylaxis (%)
Abdominal hysterectomy	7	599	100.0	100.0	71.0	94.5	99.8	100.0	100.0	100.0	99.8	-	96.0
Bile duct, liver or pancreatic surgery	2	133	100.0	100.0	56.4	99.2	100.0	100.0	100.0	100.0	100.0	-	100.0
Breast surgery	16	3,744	100.0	99.9	53.0	73.5	100.0	100.0	100.0	100.0	99.9	-	92.6
Cardiac surgery (non-CABG)	10	4,087	100.0	100.0	87.3	72.2	100.0	99.9	100.0	100.0	93.3	-	95.9
Cholecystectomy	2	92	100.0	100.0	52.2	100.0	100.0	100.0	100.0	100.0	100.0	-	46.7
Coronary artery bypass graft	13	5,964	100.0	100.0	92.2	81.6	100.0	100.0	100.0	100.0	99.9	-	99.9
Cranial surgery	7	2,023	100.0	100.0	75.3	88.2	100.0	100.0	100.0	100.0	99.9	-	91.7
Gastric surgery	8	480	100.0	100.0	42.7	66.3	99.6	100.0	100.0	100.0	99.8	-	98.8
Hip replacement	166	39,998	100.0	100.0	60.8	96.9	99.9	100.0	100.0	100.0	-	98.8	97.0
Knee replacement	157	44,217	100.0	100.0	66.6	97.2	99.9	100.0	100.0	100.0	-	98.7	97.4
Large bowel surgery	21	2,664	100.0	100.0	60.4	88.0	100.0	100.0	100.0	100.0	99.8	-	97.3
Limb amputation	7	369	100.0	100.0	18.2	57.5	98.6	100.0	100.0	100.0	99.5	-	91.9
Reduction of long bone fracture	25	3,067	100.0	100.0	19.7	87.9	100.0	100.0	100.0	100.0	99.7	-	97.1
Repair of neck of femur	79	18,489	100.0	100.0	26.6	93.9	100.0	99.9	100.0	100.0	-	99.3	98.4
Small bowel surgery	10	692	100.0	99.9	54.5	80.9	99.4	100.0	100.0	100.0	99.7	-	97.7
Spinal surgery	14	6,334	100.0	100.0	52.0	84.5	98.8	99.9	100.0	100.0	76.9	-	88.9
Vascular surgery	10	1,167	100.0	100.0	46.6	95.7	100.0	100.0	100.0	100.0	98.5	-	95.5

† results available only where this information is collected. For body mass index (BMI) this applies only to patients 16 years and older. For primary indication, this applies to joint replacement surgery only (ie hip and knee replacements, and repair of neck of femur). For trauma surgery this excludes joint replacement surgery.

Table 2: Patient and surgery-related characteristics by surgical category, NHS hospitals England, April 2017 to March 2018

	Patient-related characteristics				Surgery-related characteristics							
Surgical category	**Median age, IQR (years)**	**Male (%)**	**BMI ≥ 30 kg/m^2 (%)**	**ASA ≥ 3 (%)**	**Wound contaminated or dirty (%)**	**Median operation duration, IQR (mins)**	**Median length of stay, IQR (days)**	**Pre-op stay > 1 day (%)**	**Emergency surgery (%)**	**Multiple procedures performed (%)**	**Antibiotic not given prior to surgery (%)**	**Implant present (%)**
Abdominal hysterectomy	54 (46-66)	-	40.9	20.3	0.0	120 (94-150)	3 (1-4)	1.7	0.2	17.9	1.4	0.0
Bile duct, liver or pancreatic surgery	65 (56-72)	50.4	26.7	38.6	0.0	357 (255-475)	9 (5-16)	10.5	0.0	35.3	0.0	0.8
Breast surgery	58 (49-69)	1.1	27.5	10.8	0.5	67 (52-96)	0.5 (0.5-1)	0.2	0.1	10.5	25.7	12.3
Cardiac surgery (non-CABG)	66 (51-75)	62.7	30.6	91.3	0.0	240 (191-300)	9 (7-15)	24.6	1.7	36.6	0.4	87.0
Cholecystectomy	63 (51-73)	38.0	33.3	23.9	0.0	144 (78-385)	3 (0.5-9)	2.2	1.1	75.0	2.3	0.0
Coronary artery bypass graft	68 (60-75)	81.7	33.7	93.4	0.0	234 (195-275)	8 (6-13)	35.6	1.2	23.8	0.4	67.2
Cranial surgery	55 (39-68)	53.7	26.9	41.7	2.6	119 (63-192)	6 (3-13)	24.3	7.8	1.1	1.4	54.6
Gastric surgery	58 (46-70)	46.3	42.9	36.5	1.7	142 (107-244)	3 (1-9)	6.5	0.8	9.4	2.7	1.9
Hip replacement	71 (63-78)	39.9	37.7	25.2	0.1	83 (65-105)	3 (2-6)	4.0	0.3	-	0.5	100.0
Knee replacement	70 (62-77)	42.7	55.5	23.1	0.1	78 (61-97)	3 (3-5)	0.6	0.1	-	0.4	100.0
Large bowel surgery	69 (58-77)	50.2	23.9	40.9	18.4	165 (120-220)	8 (5-14)	15.0	6.5	13.5	1.0	1.2
Limb amputation	70 (58-78)	68.6	25.2	87.3	24.7	45 (35-57)	15 (7-30)	58.3	3.0	1.6	16.8	1.4
Reduction of long bone fracture	61 (39-79)	43.4	18.7	37.6	2.3	90 (60-114)	5 (2-14)	28.3	0.4	4.7	0.9	99.9
Repair of neck of femur	85 (78-90)	30.5	10.2	75.9	<0.1	67 (52-87)	13 (8-22)	25.9	1.1	-	2.5	100.0
Small bowel surgery	61 (44-71)	54.6	18.3	38.9	48.6	110 (75-188)	8 (5-16)	21.7	4.6	29.5	1.9	1.6
Spinal surgery	54 (37-68)	47.3	36.2	23.9	0.4	131 (89-191)	3 (1-8)	11.3	0.2	3.5	1.0	50.7
Vascular surgery	72 (65-79)	72.3	26.5	80.6	0.2	175 (126-247)	5 (2-10)	17.6	5.4	8.7	5.4	70.4

Figure 3a: Primary indication for hip replacement surgery, NHS hospitals England, April 2017 to March 2018 (N=39,513)

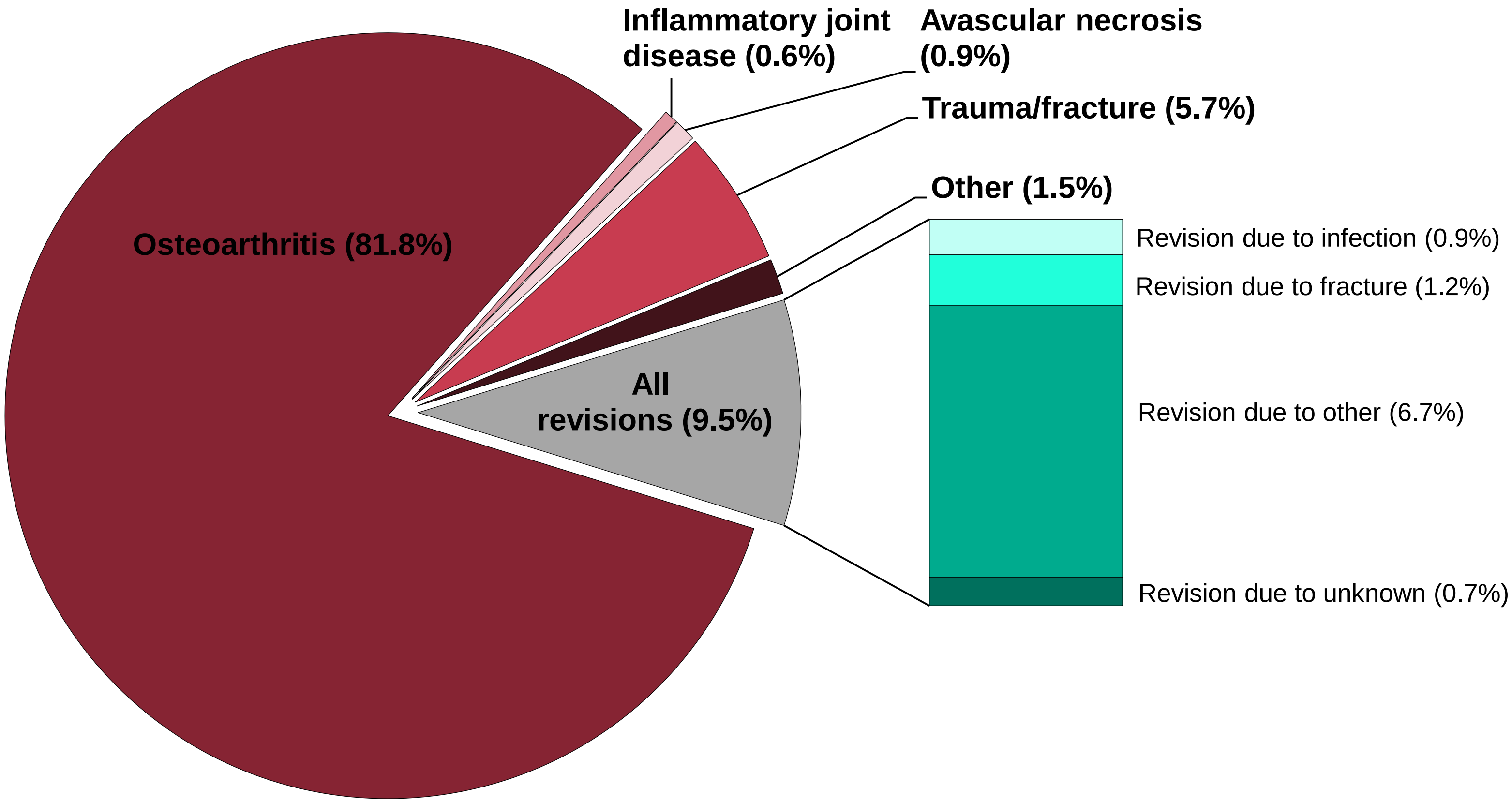
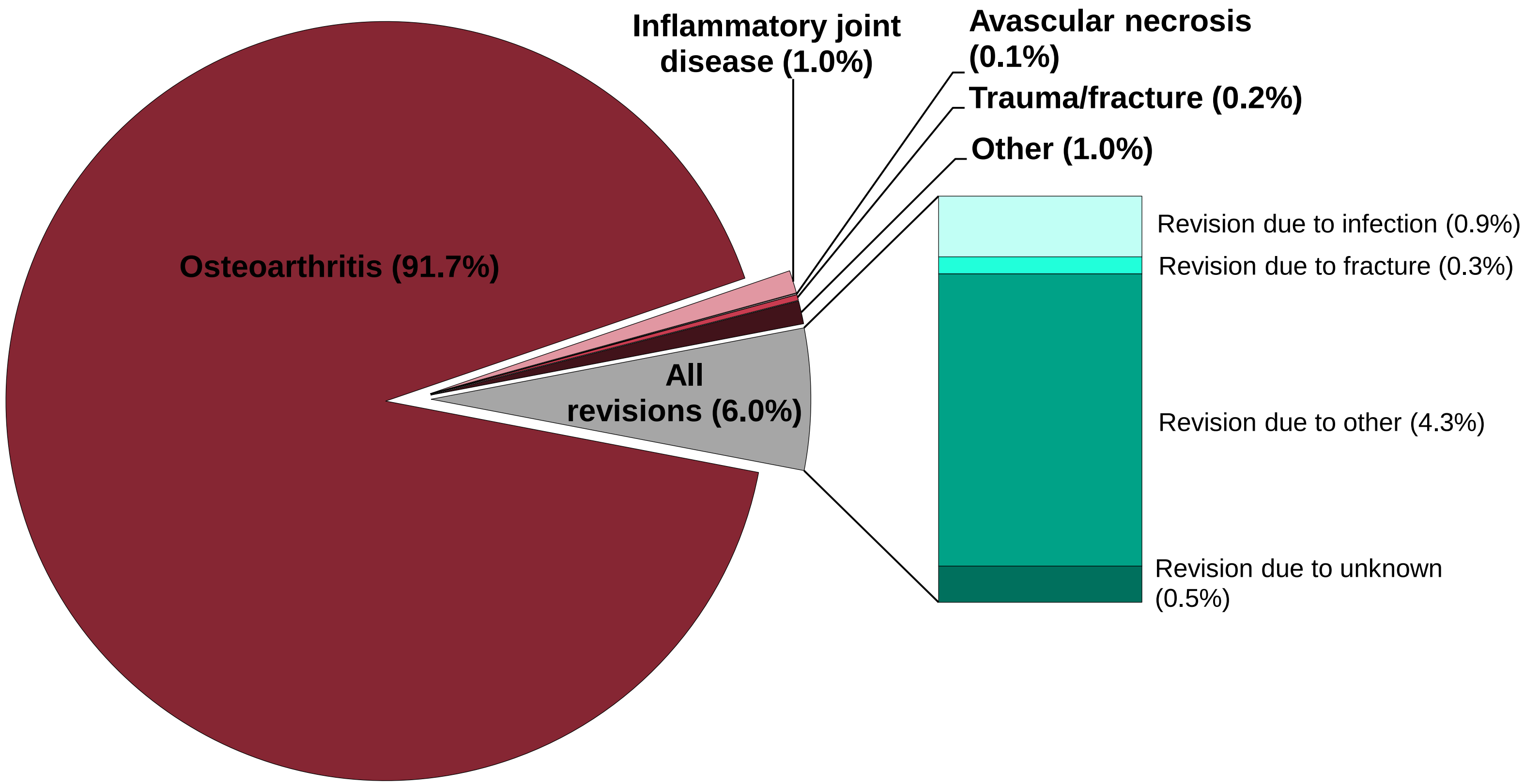


Figure 3b: Primary indication for knee replacement surgery, NHS hospitals England, April 2017 to March 2018 (N=43,647)



Assessing SSI risk

Inpatient and readmission SSI risk

Inpatient and readmission SSI risk varied considerably by surgical category. Table 3 presents the cumulative SSI incidence (risk) and incidence density by surgical category. Five years of data (April 2013 to March 2018) were used to produce robust national benchmarks.

The highest incidence (or risk) was observed in large bowel surgery at 8.7%, indicative of the high bacterial load at this surgical site. The lowest incidence was seen in hip and knee replacement surgery (0.6% and 0.5%, respectively).

For short hospital stay surgeries, such as abdominal hysterectomy, breast surgery, hip replacement, knee replacement, spinal surgery and vascular surgery, over half of SSIs were captured through readmission surveillance, emphasising the importance of post-discharge surveillance.

Using SSI incidence density to account for the differences on length of stay in capturing inpatient SSIs, the variation between surgical categories was less pronounced. Large bowel surgery remained as the highest category with an SSI incidence density of 7.0 per 1,000 inpatient days, and hip and knee surgery the lowest (0.4 per 1,000 inpatient days and 0.2 per 1,000 inpatient days, respectively). Both cholecystectomy and gastric surgery become more highly ranked when assessing incidence density, moving from the 7th and 8th position to 4th and 5th, respectively.

Table 3: Cumulative inpatient and readmission SSI incidence by surgical category, NHS hospitals England, April 2013 to March 2018

			Inpatient and readmission				Inpatient only		
Surgical category	**No. participating hospitals**	**No. operations**	**No. SSIs**	**SSI incidence (%)**	**95% CI**	**Median time to infection (days)**	**No. SSIs**	**Incidence density* (per 1,000 inpatient days)**	**95% CI**
Abdominal hysterectomy	18	2,886	47	1.6	(1.2-2.2)	11	14	1.4	(0.8-2.4)
Bile duct, liver or pancreatic surgery	7	2,161	146	6.8	(5.7-7.9)	8	129	6.7	(5.6-8.0)
Breast surgery	32	19,874	174	0.9	(0.8-1.0)	16	19	0.7	(0.4-1.2)
Cardiac surgery (non-CABG)	15	16,706	218	1.3	(1.1-1.5)	14	146	0.7	(0.6-0.8)
Cholecystectomy	9	1,861	42	2.3	(1.6-3.0)	6	22	4.6	(2.9-6.9)
Coronary artery bypass graft	22	29,339	1,020	3.5	(3.3-3.7)	13	624	2.2	(2.1-2.4)
Cranial surgery	11	8,801	146	1.7	(1.4-2.0)	19	54	0.7	(0.5-0.9)
Gastric surgery	10	2,066	46	2.2	(1.6-3.0)	8	40	2.6	(1.9-3.6)
Hip replacement	189	200,848	1,174	0.6	(0.5-0.6)	17	381	0.4	(0.3-0.4)
Knee replacement	179	213,615	1,096	0.5	(0.4-0.5)	20	249	0.2	(0.2-0.3)
Large bowel surgery	50	18,659	1,623	8.7	(8.3-9.1)	8	1,370	7.0	(6.7-7.4)
Limb amputation	13	1,916	51	2.7	(2.0-3.5)	13	37	1.6	(1.1-2.2)
Reduction of long bone fracture	37	12,608	127	1.0	(0.8-1.2)	17	71	0.6	(0.5-0.8)
Repair of neck of femur	113	96,020	1,007	1.1	(1.0-1.1)	16	693	0.4	(0.4-0.5)
Small bowel surgery	21	4,503	302	6.7	(6.0-7.5)	8	257	5.0	(4.4-5.7)
Spinal surgery	25	36,524	522	1.4	(1.3-1.6)	14	231	1.0	(0.9-1.2)
Vascular surgery	18	6,050	149	2.5	(2.1-2.9)	14	72	1.6	(1.3-2.1)

Notes
*10 observations excluded due to missing or invalid operation/discharge dates.

Inpatient days were calculated using the date inpatient surveillance stopped as a proxy for discharge date. The primary reason for stopping inpatient surveillance is that the patient has been discharged from hospital however, it may underestimate where patients are still in hospital but surveillance follow-up has been completed (30 days without implant and 1 year with a prosthetic implant).

Risk factors for SSI

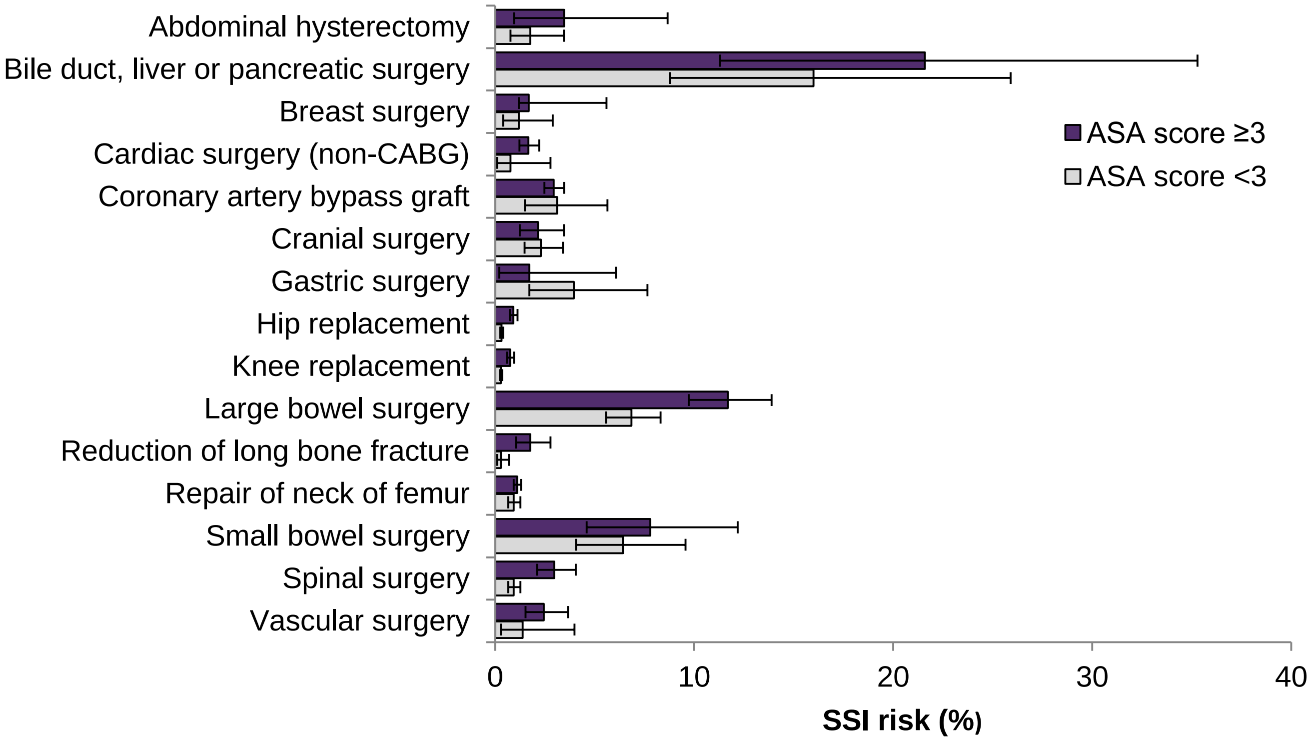
Key patient and surgery-related characteristics were captured through the SSI surveillance programme. Figure 4 shows the SSI incidence (or risk) stratified according to some of these key risk factors. These include patient obesity, as well as those which form the NHSN Risk Index (see *glossary* for definition): ASA score ≥3, operation duration >75th percentile as defined by 'T-time', and a contaminated or dirty wound. Only surgical categories where patient risk factor groups had sufficient volumes were analysed (≥100 procedures for abdominal hysterectomy, hip replacement and knee replacement surgery; ≥50 procedures for all other categories).

For the majority of surgical categories (12 of 15), patients with an ASA score ≥3 were at an increased risk of infection. Similarly, an operation duration >'T time' (75th percentile) increased the risk of an SSI across the majority of all surgical categories (13 of 15). The proportion of procedures with a contaminated or dirty wound classification was <3% for 14 of the 17 surgical categories (Table 2). However of the 6 surgical categories with a sufficient number of patients with a contaminated or dirty wound procedure, SSI risk was consistently higher among the high risk patient group (4 of 6). The difference in SSI risk was statistically significant (95% confidence intervals did not overlap) for large bowel surgery. BMI analysis was restricted to hospitals with 70% or more completion for that participating surveillance quarter. The majority (11 of 14) of surgical categories showed that SSI risk increased among patients who were obese. The difference in SSI risk was statistically significant for coronary artery bypass graft, where obese patients were about twice as likely as non-obese patients to be at risk of SSI following surgery.

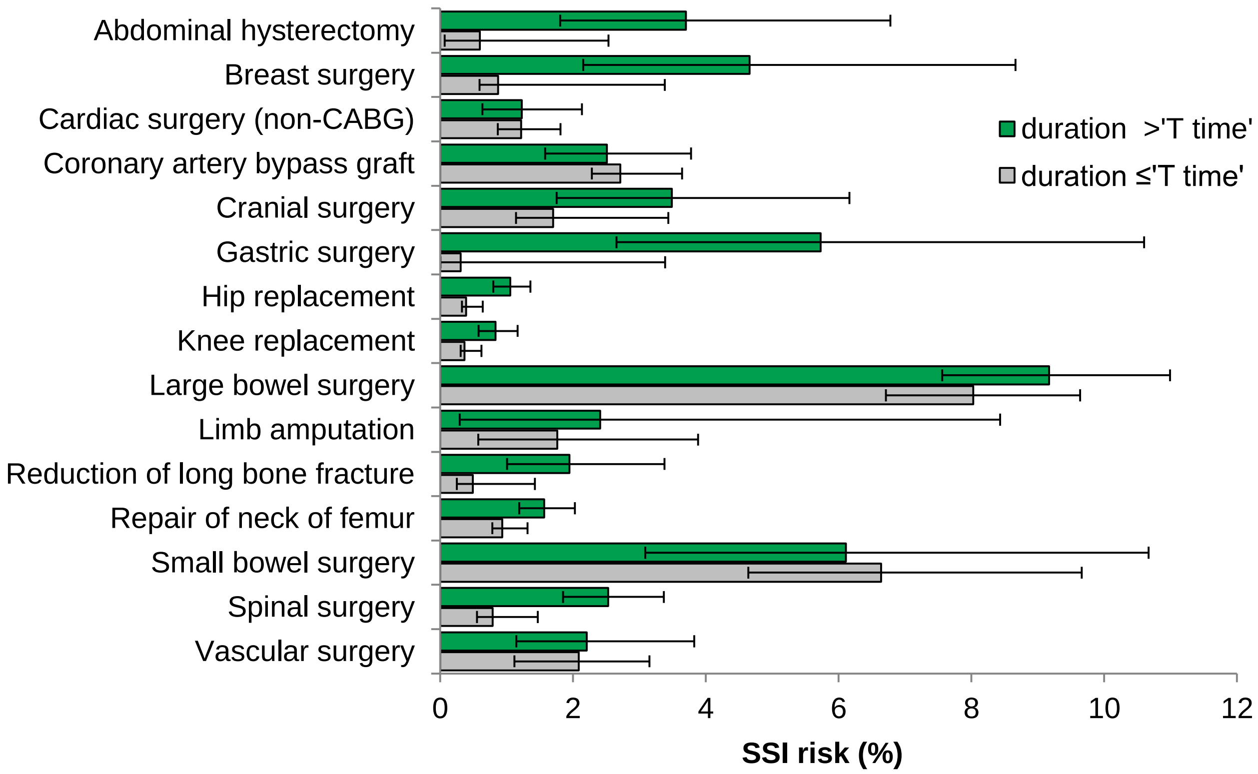
Table 4 shows the SSI incidence by the primary indication for surgery (primary or revision), an important risk factor for SSI following hip replacement and knee replacement surgery. For both hip and knee replacement surgery, revision procedures carried a much higher SSI risk than primary procedures (4 times higher and 3 times higher, respectively). Among primary procedures, procedures carried out to manage avascular necrosis or trauma were associated with increased SSI risk (hip: 0.8% and 0.7%, respectively; knee: 4.8% and 3.8%, respectively). Although more pronounced among knee replacement, very few avascular necrosis-related knee replacement procedures were submitted in 2017/18 (21 procedures). SSI incidence estimates calculated for primary indication surgery groups with <100 procedures should be interpreted with caution.

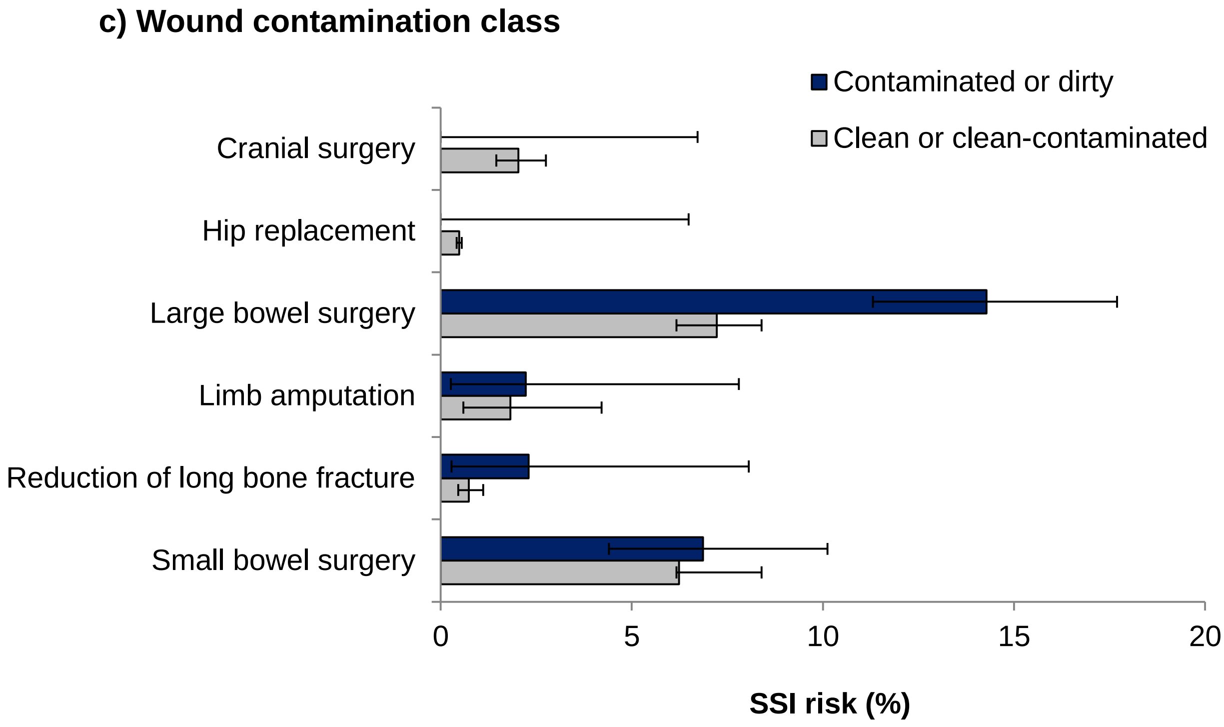
Figures 4a-d: Inpatient and readmission SSI incidence by risk factor (ASA score, operation duration, wound class, BMI), NHS hospitals England, April 2017 to March 2018

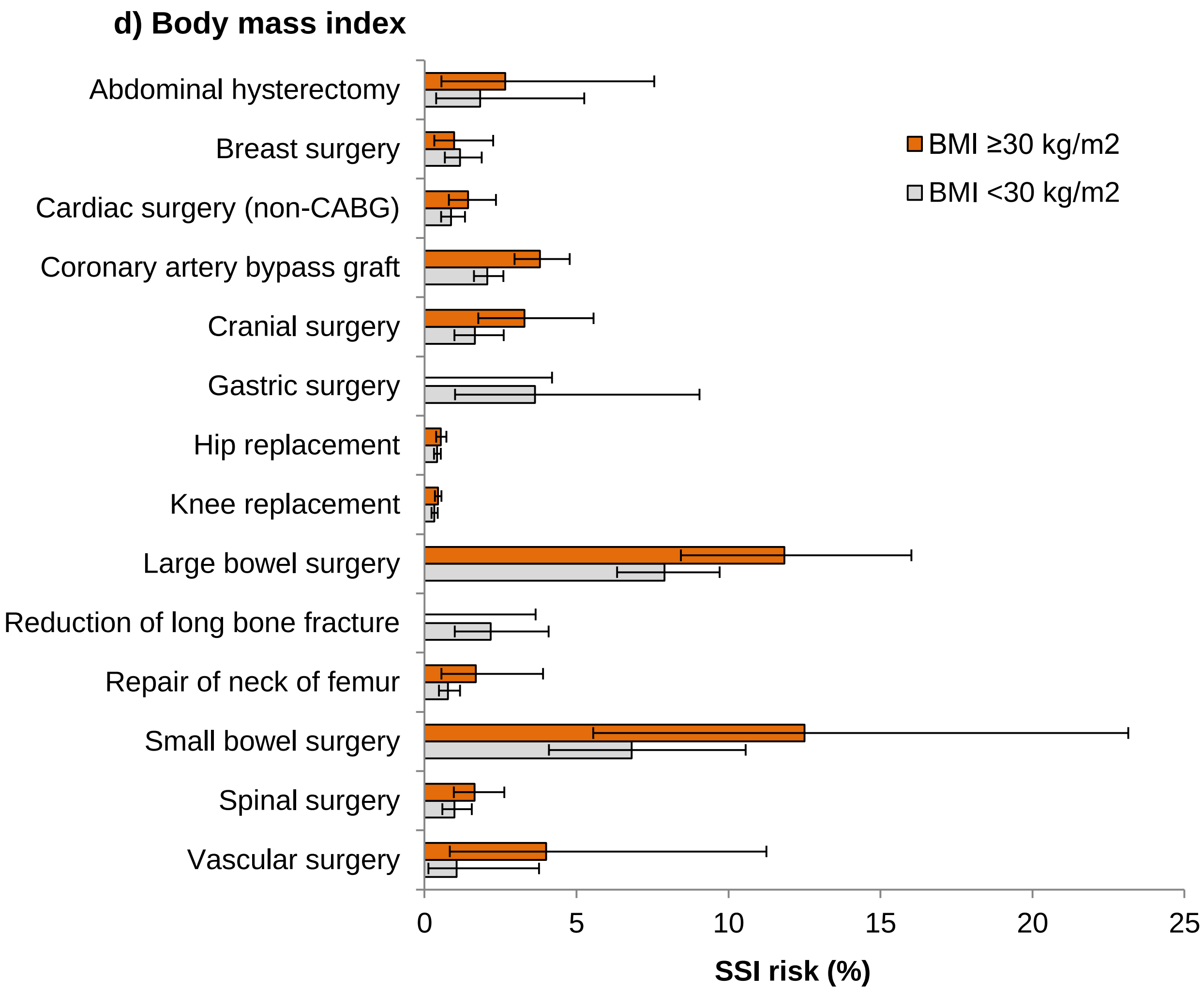
a) ASA score



b) Operation duration







Notes
Where there is no bar signifying SSI risk, there were no SSI cases reported within that risk group for the given time period.

Table 4: Inpatient and readmission SSI incidence by primary indication for joint replacement surgeries, NHS hospitals England, April 2017 to March 2018

Primary Indication		Hip replacement No. operations	Hip replacement No. SSI	Hip replacement SSI risk (%)	Knee replacement No. operations	Knee replacement No. SSI	Knee replacement SSI risk (%)
Primary procedures	Osteoarthritis	32,316	109	0.3	40,043	139	0.3
	Inflammatory joint disease	236	0	0.0	423	1	0.2
	Avascular necrosis	362	3	0.8	21	1	4.8
	Trauma/fracture	2,251	16	0.7	106	4	3.8
	Other	585	2	0.3	426	2	0.5
	All	**35,750**	**130**	**0.4**	**41,019**	**147**	**0.4**
Revision procedures	Infection	345	5	1.4	393	9	2.3
	Fracture	494	18	3.6	110	1	0.9
	Other	2,648	32	1.2	1,891	19	1.0
	Unknown	276	5	1.8	234	3	1.3
	All	**3,763**	**60**	**1.6**	**2,628**	**32**	**1.2**

Trends in SSI risk

Figure 6 shows annual trends in SSI incidence for all surgical categories. SSI incidence is broken down by detection method: inpatient, readmission and combined inpatient and readmission. Trend analyses were not performed for surgical categories with <5 participating hospitals in the most recent financial year.

Over the past 9 years, inpatient and readmission SSI incidence following hip and knee replacement surgery has been relatively stable. In 2017/18 the rate for hip replacement decreased slightly to 0.5% (Figure 6a). Similarly, inpatient and readmission SSI risk following knee replacement decreased slightly in 2017/18 to 0.4% (Figure 6b). For both hip and knee replacement, greater declines over time have been observed for infections occurring among inpatients compared to those detected on readmission. However, in 2017/18 a decrease in incidence of SSIs was noted in the latter.

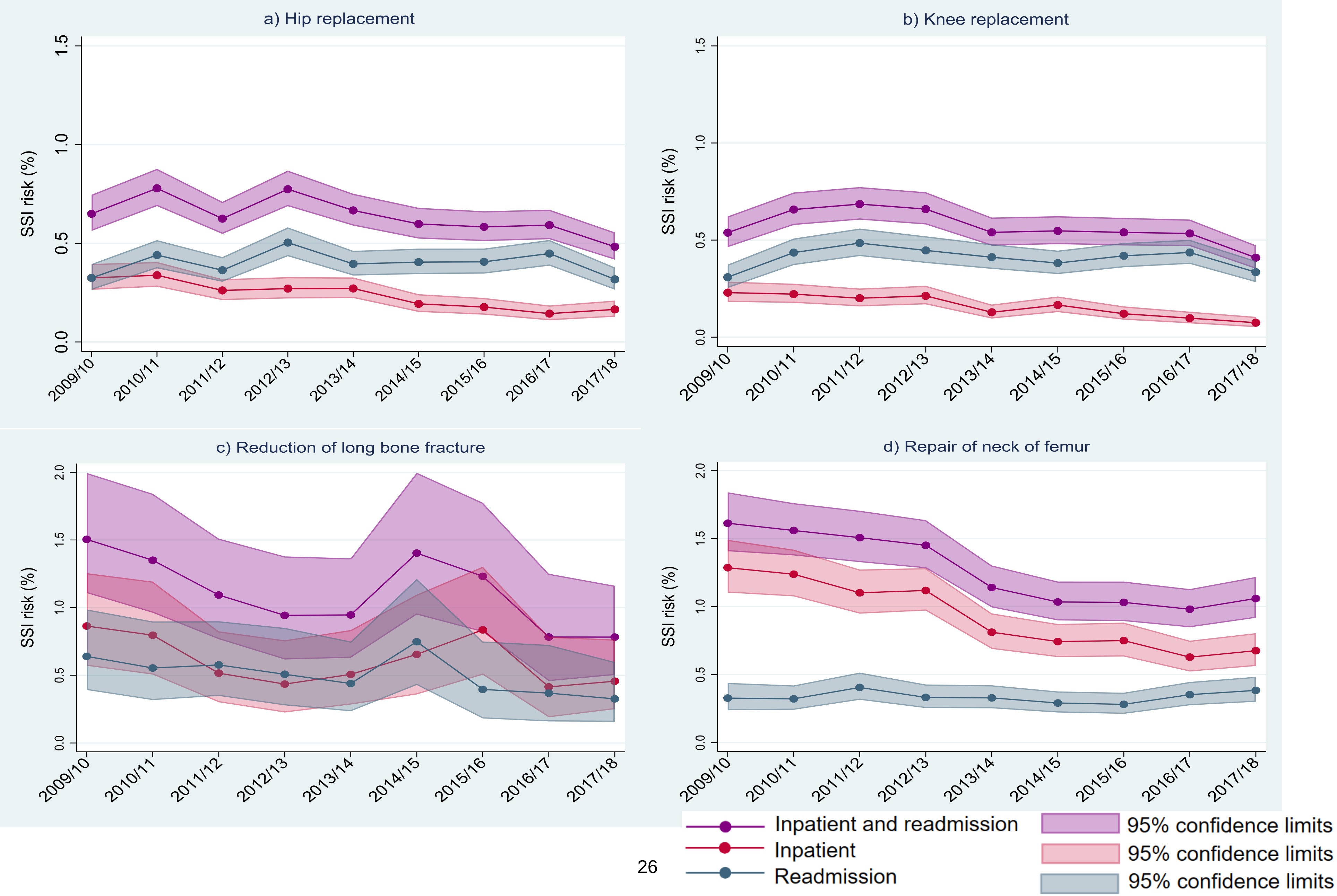
SSI trends for reduction of long bone fracture have shown greater variability over the years (Figure 6c). After a peak in 2014/15, the rate showed a decreasing trend and has remained at 0.7% for the last 2 financial years. Repair of neck of femur has seen a continuous decline in the inpatient and readmission SSI incidence from 2009/10, and has hovered around 1% since 2014/15 (Figure 6d). The decrease in incidence in large part reflects a reduction in the incidence of inpatient-detected SSIs.

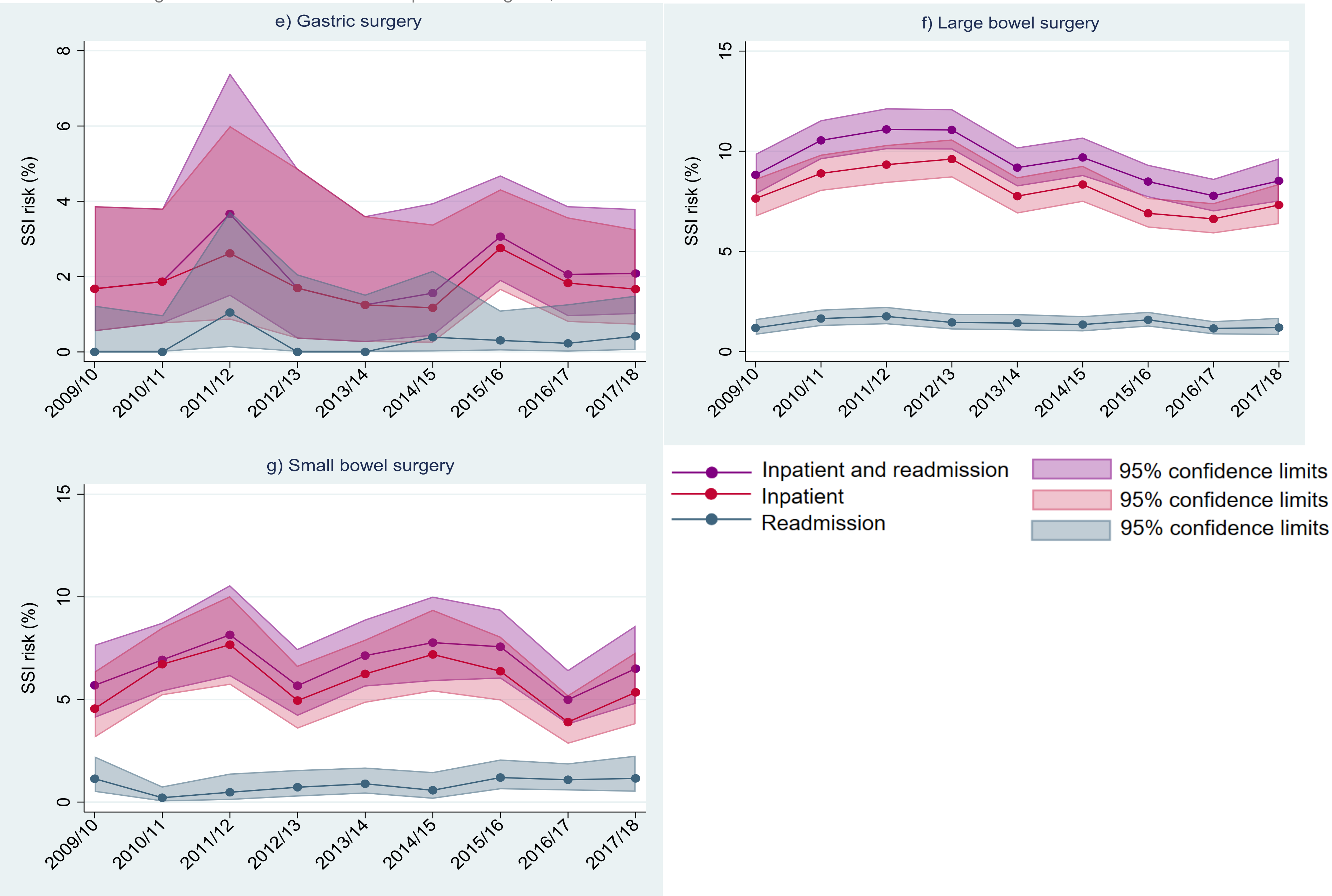
The remaining graphs look at trends for the voluntary surveillance categories. Among the gastro-intestinal categories, large and small bowel surgery showed an increase in SSI risk in 2017/18 after a downward trend from 2014/15 to 2016/17, reaching 8.5% and 6.5% (Figures 6f-g). These seem to reflect changes in the inpatient SSI incidence, as the incidence of SSIs detected on readmission remained stable.

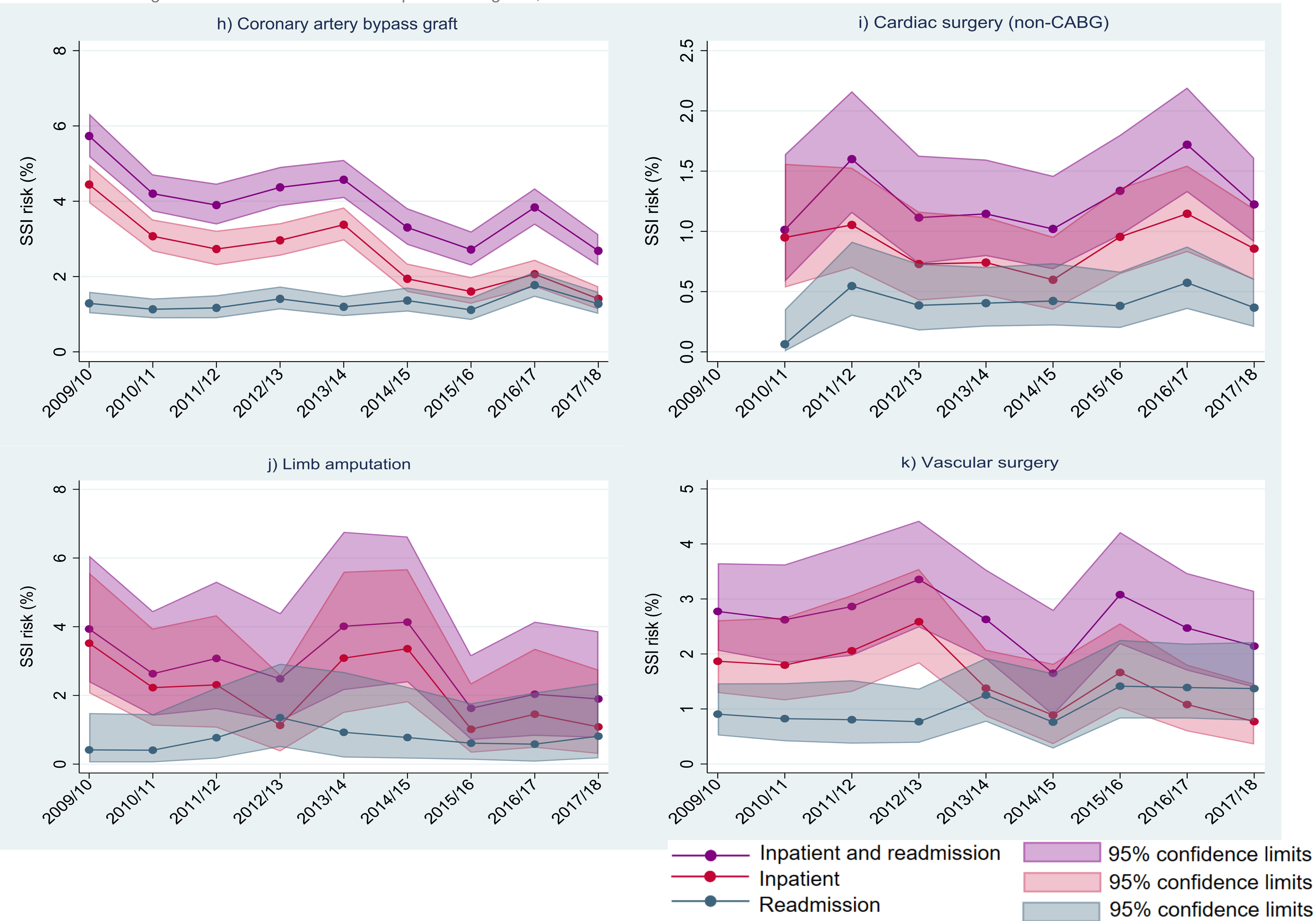
There were no discernible trends among the cardiac and vascular surgical categories (Figures 6h-k). Both cardiac surgeries (CABG and non-CABG) showed a lower SSI risk in 2017/18 after a peak in 2016/17. Similar fluctuations were seen for vascular surgery however, a general declining trend has been observed since 2015/16. This was largely attributed to the changes in inpatient SSI incidence.

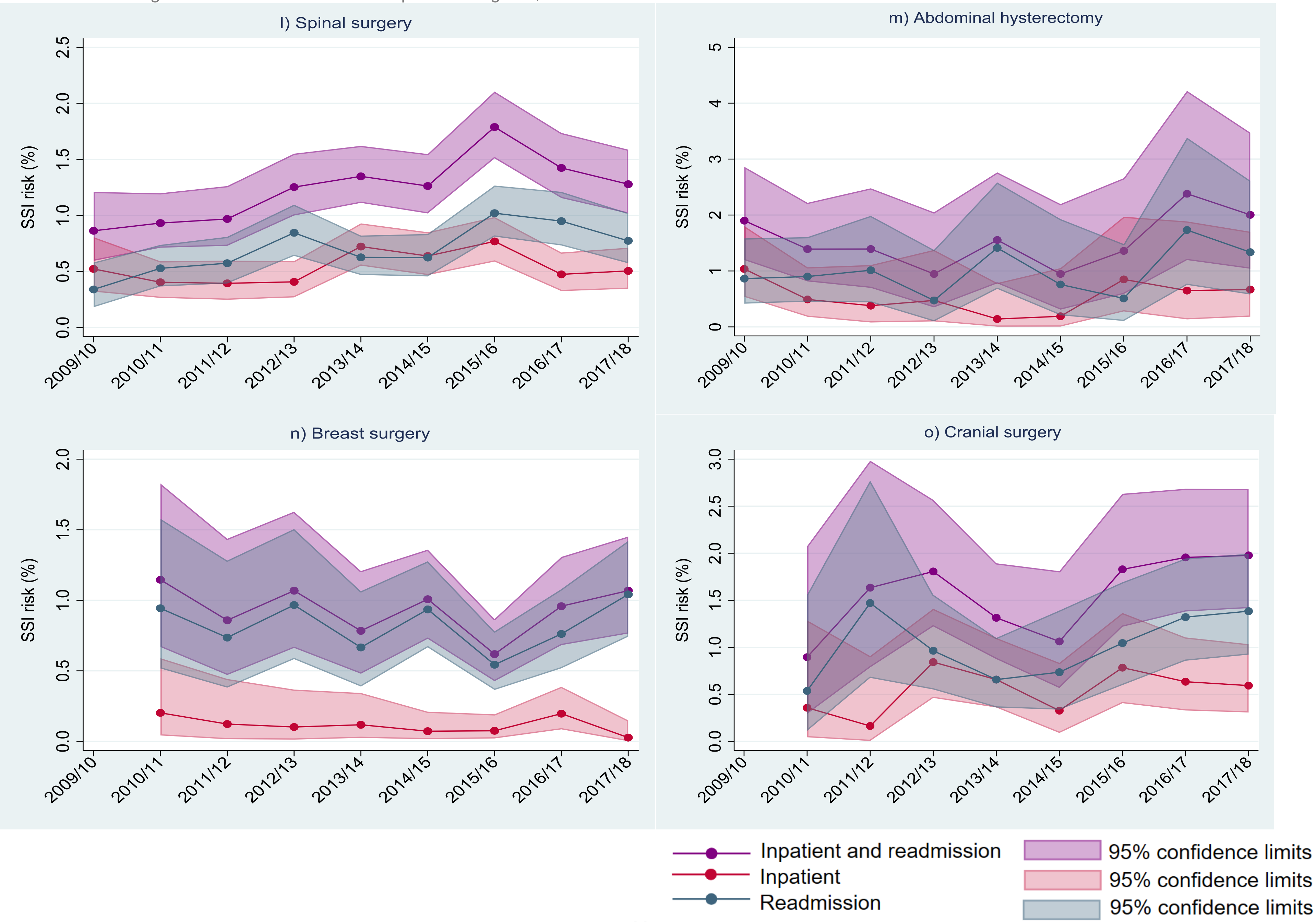
Among the remaining surgical categories there were no sustained trends (Figures 6l-o). Of note, spinal surgery continued to decrease in 2017/18 (1.3%) after a peak in 2015/16 (1.8%). Cranial surgery which has shown an overall increase from 2010/11 to 2016/17 (0.9% to 2%), remained stable in 2017/18 at 2%. It is important to note that annual trends use crude SSI incidence and do not account for potential changes in risk factors for SSI over time.

Figures 6a-o: Trends in annual SSI incidence for all surgical categories, NHS hospitals England, April 2009 to March 2018




e) Gastric surgery
SSI risk (%)
0
2
4
6
8
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
f) Large bowel surgery
SSI risk (%)
0
5
10
15
g) Small bowel surgery
SSI risk (%)
Inpatient and readmission
Inpatient
Readmission
95% confidence limits
95% confidence limits
95% confidence limits


h) Coronary artery bypass graft
i) Cardiac surgery (non-CABG)
j) Limb amputation
k) Vascular surgery
SSI risk (%)
0
2
4
6
8
0.0
0.5
1.0
1.5
2.0
2.5
0
1
2
3
4
5
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
Inpatient and readmission
Inpatient
Readmission
95% confidence limits
95% confidence limits
95% confidence limits

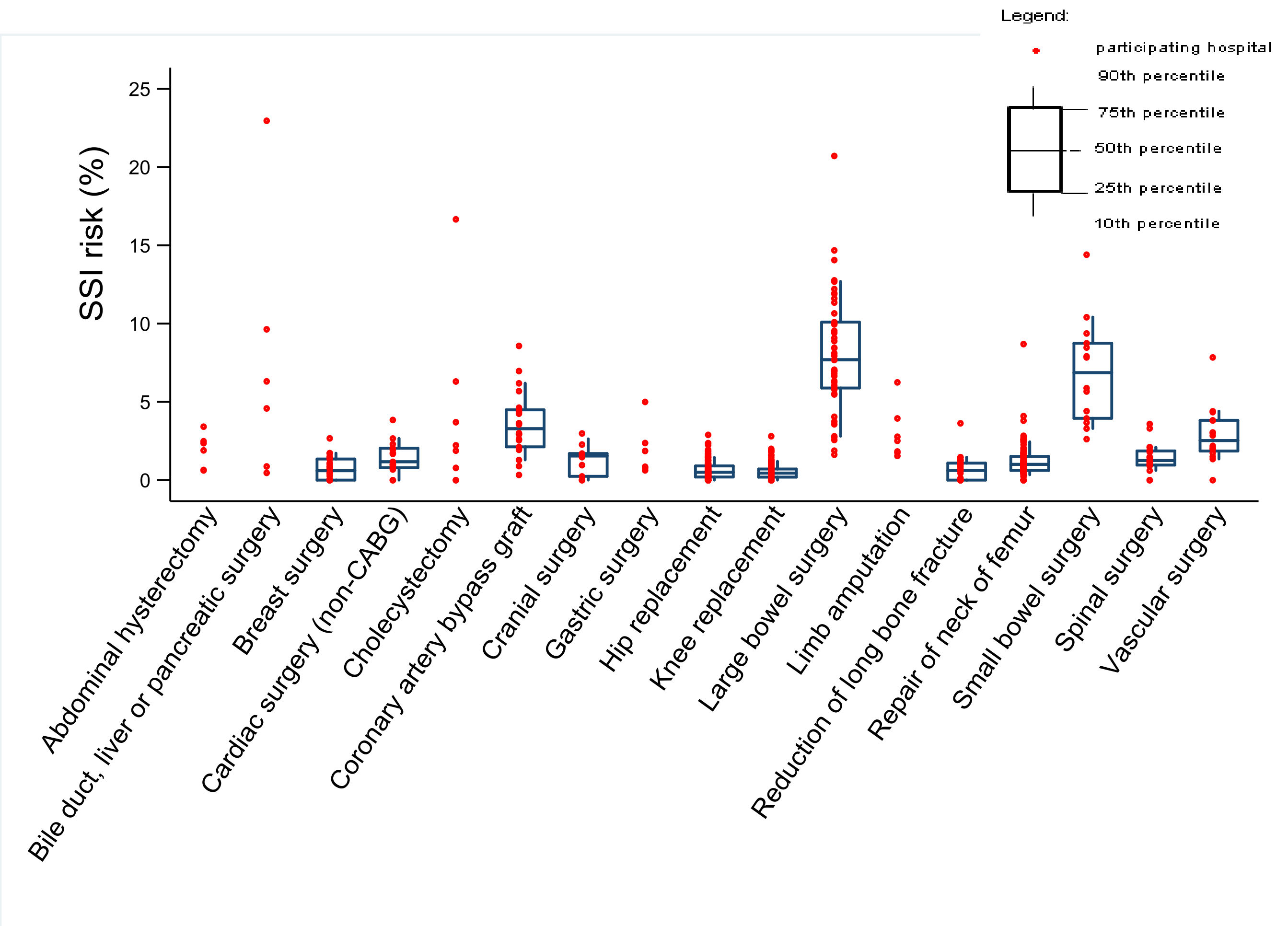

l) Spinal surgery
m) Abdominal hysterectomy
n) Breast surgery
o) Cranial surgery
SSI risk (%)
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
Inpatient and readmission
Inpatient
Readmission
95% confidence limits
95% confidence limits
95% confidence limits

Variation in SSI risk between hospitals

Figure 7 shows the distribution of SSI cumulative incidence across participating hospitals by surgical category using box-and-whisker plots. The box is formed of a lower quartile (25th to 50th percentile) and an upper quartile (50th to 75th percentile). The "whiskers", which are used to indicate variability outside the upper and lower quartile, use the 10th and 90th percentile to represent the extreme ends of the distribution and highlight hospital outliers. Each red dot represents a participating hospital.

Among those surgical categories with ≥10 participating hospitals, large bowel surgery showed the greatest variability, with inpatient and readmission SSI risks ranging from 1.6% to 20.7% among participating hospitals, indicating that there may be room for improvement across hospitals. Hip replacement and knee replacement show the least variation, with the majority of data points hovering around the median. However, high outlier hospitals can still be identified for these surgical categories. The level of variation within surgical categories remained fairly consistent with that observed from April 2012 to March 2017. The only noted reduction was for large bowel surgery where the interquartile range (difference between the 75th and 25th percentiles) narrowed by 2%.

Figure 7: Distribution of inpatient and readmission SSI risk, NHS hospitals England, April 2013 to March 2018



Notes

Hospitals with <95 operations for hip replacement, knee replacement and abdominal hysterectomy were excluded. For all other surgical categories a threshold of 45 or more operations was used. Categories with <10 hospitals participating within this time period were presented as a distribution without a box plot.

Outlier assessment

For the mandatory orthopaedic categories, outliers are assessed at the end of each financial year across all NHS trusts using funnel plots, which account for differences in surgical volume. In 2017/18, there was 1 NHS trust performing orthopaedic surgeries that did not participate in surveillance and was notified by the SSISS.

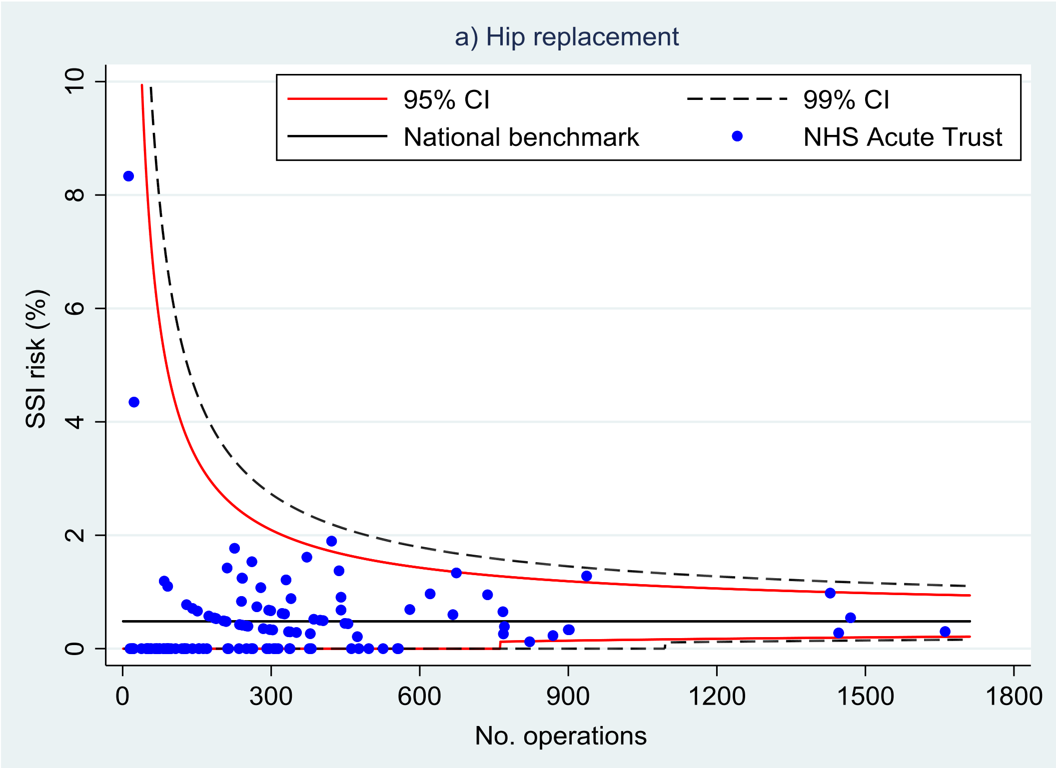
Figures 8a-d show funnel plots displaying variation in the incidence of SSIs among trusts in 2017/18 for orthopaedic categories. The cumulative incidence of SSI per 100 procedures is plotted against the number of procedures for each participating NHS acute trust. The upper and lower 95% confidence limits (red lines) define the 'limits' of expected variation. Trusts lying outside these limits are considered to be outliers. The 99% confidence limits are presented to represent the expected variation within which 99% of results should fall. 95% confidence intervals are considered to be warning lines, whereas falling outside of the 99% confidence limits would signify the need for action.

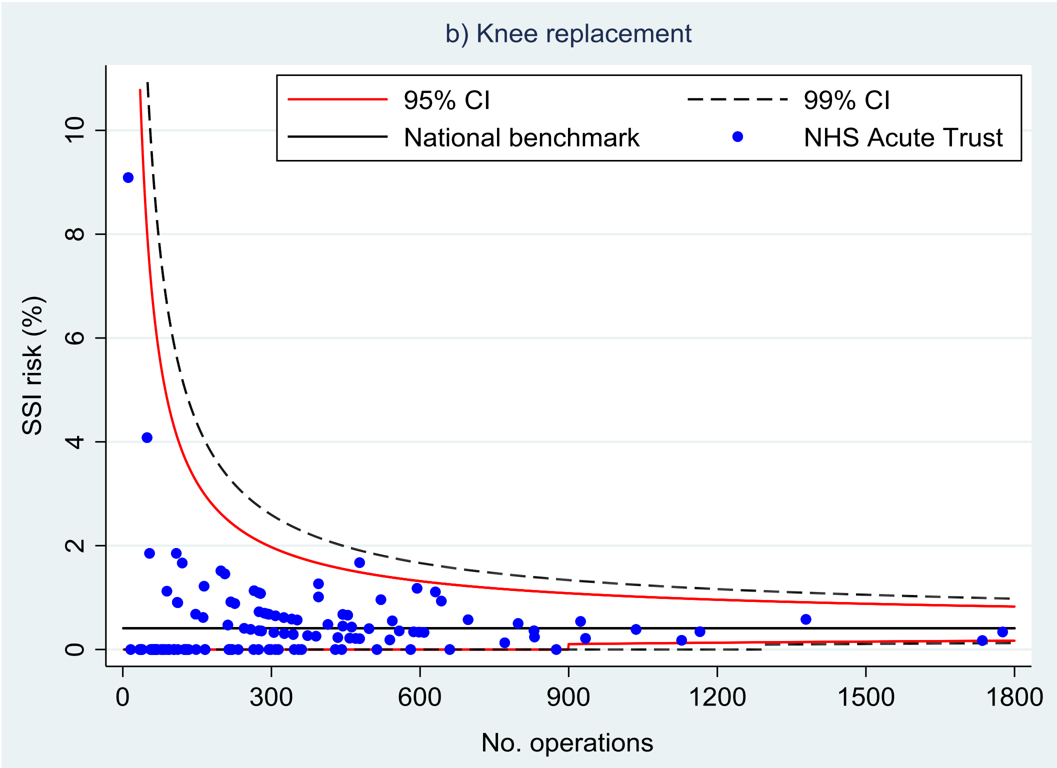
Results for 2017/18 showed less variation in results and more consistent grouping around the national benchmark. Four NHS acute trusts were identified as statistical outliers (falling outside of the 95% confidence limits). However, none of these acute trusts fell outside of the 99% confidence limits. Of these 4 acute trusts, 3 were high outliers and 1 was a low outlier. One trust was a high outlier for both the hip and knee replacement surgical categories and the low outlier trust was a low outlier for both hip replacement and repair of neck of femur. Two trusts had been notified as outliers in the previous year as well for the same surgical categories.

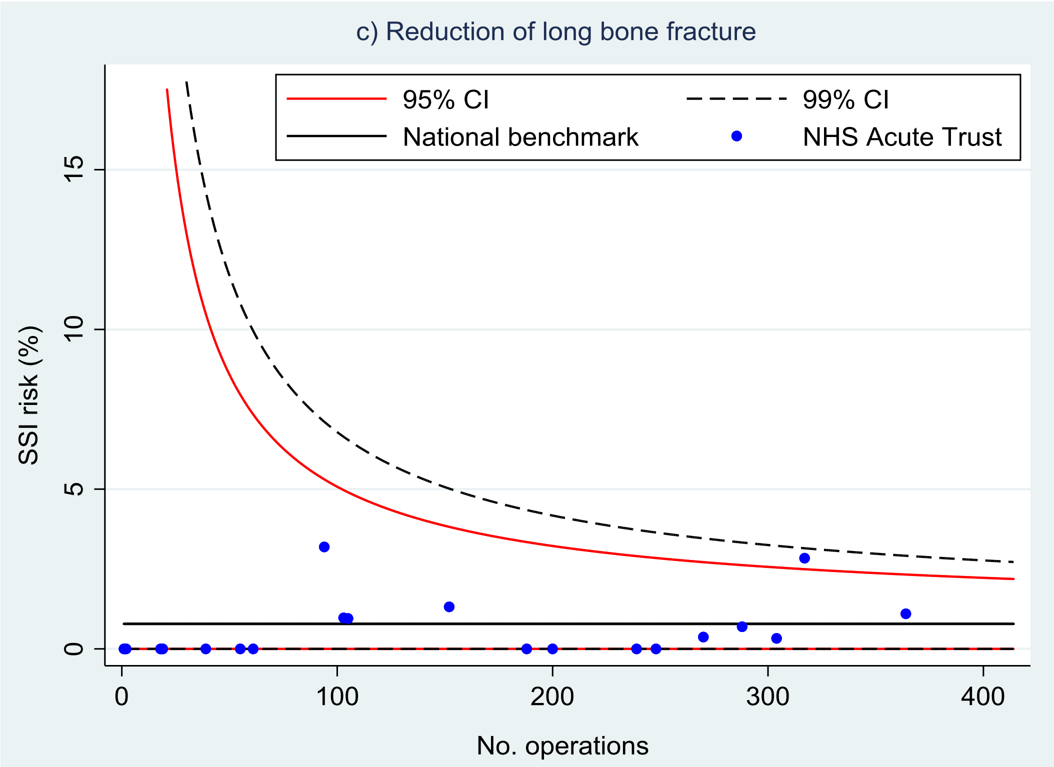
As part of this report, SSI risk results by NHS acute trust (and NHS treatment centre) for 2017/18 can be found published in separate accompanying tables here:

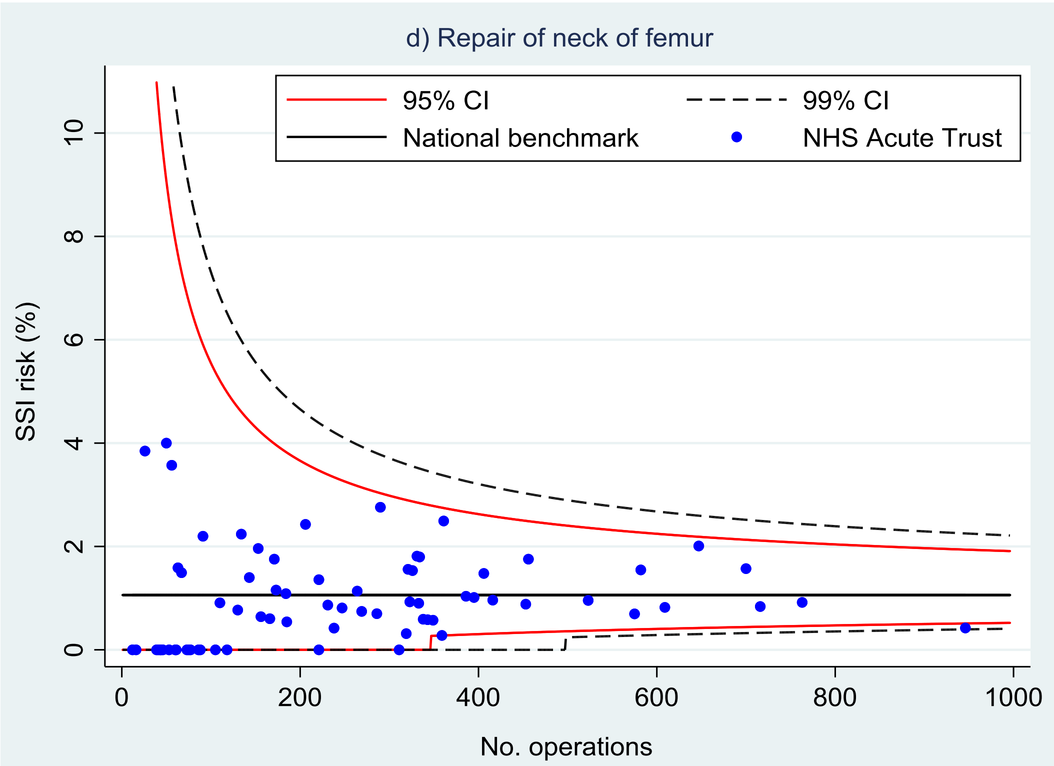
www.gov.uk/government/publications/surgical-site-infections-ssi-surveillance-nhs-hospitals-in-england

Figure 8a-d: Distribution of inpatient and readmission SSI incidence, NHS acute trusts England, orthopaedic surveillance, April 2017 to March 2018






c) Reduction of long bone fracture
95% CI
99% CI
National benchmark
NHS Acute Trust
SSI risk (%)
0
5
10
15
0
100
200
300
400
No. operations


d) Repair of neck of femur
95% CI
99% CI
National benchmark
NHS Acute Trust
SSI risk (%)
0
2
4
6
8
10
0
200
400
600
800
1000
No. operations

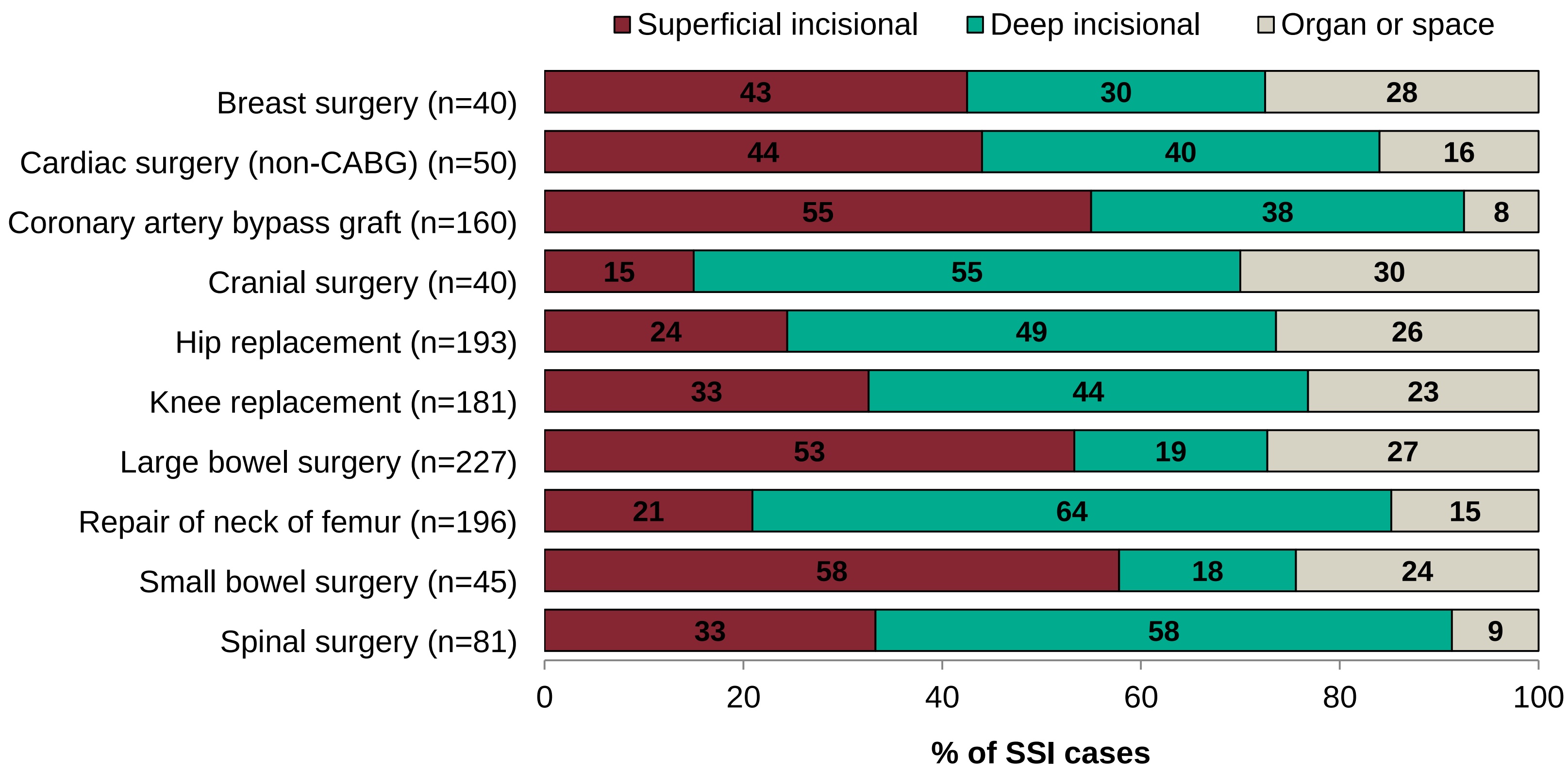
Characteristics of SSIs

Focus of SSI

In 2017/18 there were 1,338 inpatient and readmission-detected SSIs reported. Figure 8 shows the distribution of SSI type for 2017/18 by surgical category indicating the site of infection. Surgical categories with less than 40 inpatient and readmission SSIs were not included in these analyses.

The proportion of SSIs classified as superficial incisional varied by surgical category, ranging from 15% for cranial surgery to 58% for small bowel surgery. Differences in proportions may be affected by the variation in duration of hospital stay. Surgical categories with a shorter duration in hospital see relatively more readmission-detected SSIs, which in turn increases the proportion of more serious wound complications. However, despite being a procedure with a short inpatient stay, breast surgery had a higher proportion of superficial incisional SSIs (43%) compared to other short inpatient stay procedures such as hip or knee replacement surgery (24% and 33%, respectively). Repair of neck of femur and cranial surgery showed the highest proportion of deep incisional and organ-space SSIs (79% and 85%, respectively).

Figure 8: Distribution of SSI type for inpatient and readmission detected cases, by surgical category, NHS hospitals England, April 2017 to March 2018

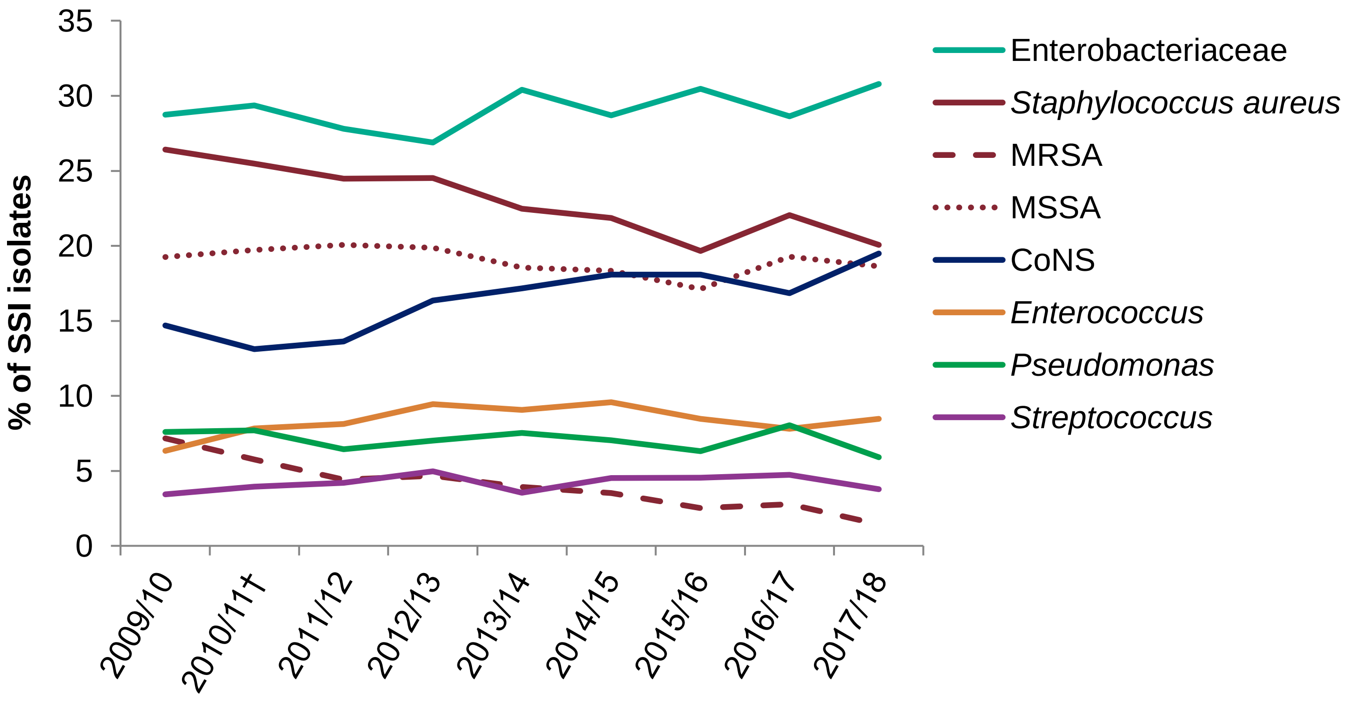


Causative organisms

Figure 9 shows trends in microbial aetiology of inpatient and readmission-detected SSIs from April 2009 to March 2018 based on data from all surgical categories. During this time period there were 15,011 inpatient and readmission-detected SSIs reported, 67% (N=10,027) of which had accompanying microbiology data. It is important to note, that cranial, breast and cardiac (non-CABG) surgical categories were added to the surveillance programme in April 2010.

The proportion of isolates that were Enterobacteriaceae increased from 28.6% in 2016/17 to 30.8% in 2017/18. Fluctuations have been observed since 2013/14, however. Between 2016/17 to 2017/18 the greatest per cent increase was for coagulase-negative staphylococci (CoNS), which had gradually increased since 2009/10, from 14.7% to 19.5%. Looking across all 9 years, (2009/10 to 2017/18), *Staphylococcus aureus*, showed the greatest relative decline (26.4% to 20%), which was largely driven by decreases in methicillin-resistant *S. aureus* (MRSA). MRSA accounted for only 1.4% of SSIs in 2017/18 however, so the largest proportion of *Staphylococcus aureus* organisms causing SSI remains the methicillin-sensitive form (MSSA: 19.5% in 2017/18).

Figure 9: Micro-organisms reported as causing SSI for inpatient and readmission detected cases, all surgical categories, NHS hospitals England, April 2009 to March 2018



Notes

†new surgical categories added to the surveillance programme in 2010/11: cardiac (non-CABG), breast surgery, and cranial surgery.

Tables 5-6 break down the distribution of organisms reported as causing inpatient and readmission-detected SSIs by surgical category. Five years of data were used for these analyses (April 2013 to March 2018) to ensure sufficient volumes. Table 5 provides the distribution for all types of SSI infections and Table 6 looks specifically at deep or organ-space infections. Surgical categories included in this analysis had ≥ 100 cases with available microbiology information. Spinal surgery had the highest proportion of SSI cases with available microbiology information (83%). Over 80% of cases had microbiology information provided for hip replacement and repair of neck of femur surgical categories as well. Large bowel surgery had the lowest proportion of SSI cases with microbiology data (53%). Polymicrobial SSIs (cases with more than 1 organism reported as causing SSI) were most frequent in large bowel surgery at 40% of cases and lowest in knee replacement surgery at 24%, reflecting the level of wound contamination inherent to these procedures.

Among monomicrobial SSIs (1 organism reported as causing SSI), MSSA remained the dominant causative organism for hip replacement, knee replacement, repair of neck of femur and spinal surgery (29.5%, 39.7%, 28.9% and 41% respectively). SSIs caused by Enterobacteriaceae were highest in large bowel surgery, making up more than half of all cases (53%) but were also responsible for significant proportions of SSIs in CABG (28.5%), repair of neck of femur (24.9%), and hip replacement (21%) procedures. CoNS, which are associated with implants, were highest in CABG surgery (26%), followed closely by spinal surgery (25.5%), knee replacement (24.9%) and hip replacement (24.2%).

Similar distributions of pathogens are seen in monomicrobial SSIs causing deep and organ-space SSIs (Table 6). Of note, the proportion of MSSA isolates was lower (2.5% vs. 5.4%) compared to all SSIs for large bowel surgery and the proportion due to Enterobacteriaceae higher (59.2% vs. 53%).

Among polymicrobial SSIs, the proportion of SSIs caused by combinations of Gram-negative bacteria were generally low. The highest percentages of such combinations were seen for large bowel surgery and CABG (21.9% and 21.2%, respectively). Across all surgical categories, about half of all polymicrobial infections comprised a combination of Gram-positive and Gram-negative infections, ranging from 33.6% for spinal surgery to 50.4% for large bowel surgery.

Polymicrobial SSIs for deep and organ-space SSIs (Table 6) showed a similar pattern. The proportion of deep and organ-space only SSIs caused by Gram-positive combinations was slightly higher across all surgeries when compared to all SSIs, except large bowel surgery which remained relatively similar. When comparing Gram-positive combination polymicrobial infections for all SSI to deep and organ-space SSI only, spinal surgery saw the largest increase in this group (50.0% to 57.9%). The largest increase in Gram-negative combinations was seen for CABG (21.2% to 25.3%) when comparing all polymicrobial SSI to deep and organ-space polymicrobial SSI only.

Table 5: Micro-organisms reported as causing inpatient and readmission detected SSIs (all SSIs), by surgical category*, NHS hospitals England, April 2013 to March 2018

		Hip replacement		Knee replacement		Repair of neck of femur		Large bowel surgery		Spinal surgery		Coronary artery bypass graft	
	Reported causative organism	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Monomicrobial	Methicillin-sensitive *S.aureus*	191	29.5	236	39.7	158	28.9	28	5.4	132	41.0	99	22.2
	Methicillin-resistant *S.aureus*	27	4.2	24	4.0	59	10.8	11	2.1	6	1.9	18	4.0
	Coagulase-negative staphylococci	157	24.2	148	24.9	93	17.0	10	1.9	82	25.5	116	26.0
	Enterobacteriaceae	136	21.0	66	11.1	136	24.9	275	53.0	56	17.4	127	28.5
	Pseudomonas	24	3.7	17	2.9	27	4.9	58	11.2	15	4.7	44	9.9
	Streptococcus	39	6.0	43	7.2	14	2.6	23	4.4	9	2.8	5	1.1
	Enterococcus	38	5.9	23	3.9	33	6.0	30	5.8	6	1.9	8	1.8
	Other bacteria	35	5.4	36	6.1	22	4.0	65	12.5	15	4.7	27	6.1
	Fungi including *Candida* spp.	1	0.2	1	0.2	5	0.9	19	3.7	1	0.3	2	0.4
	Total monomicrobial	**648**	**100**	**594**	**100**	**547**	**100**	**519**	**100**	**322**	**100**	**446**	**100**
Polymicrobial	Gram-positive combinations only	123	40.6	74	39.6	79	28.7	11	3.2	55	50.0	59	21.5
	Gram-negative combinations only	39	12.9	22	11.8	38	13.8	75	21.9	13	11.8	58	21.2
	Gram positive and Gram-negative combinations	129	42.6	79	42.2	130	47.3	173	50.4	37	33.6	132	48.2
	Other	12	4.0	12	6.4	28	10.2	84	24.5	5	4.5	25	9.1
	Total polymicrobial	**303**	**100**	**187**	**100**	**275**	**100**	**343**	**100**	**110**	**100**	**274**	**100**
	Total cases**	**951**	**100**	**781**	**100**	**822**	**100**	**862**	**100**	**432**	**100**	**720**	**100**

Notes

* surgical categories with ≥ 100 cases with available microbiology information were included.

**total cases for analyses refer to those with available microbiology information.

Table 6: Micro-organisms reported as causing inpatient and readmission detected SSIs (deep and organ space only), by surgical category*, NHS hospitals England, April 2013 to March 2018

		Hip replacement		Knee replacement		Repair of neck of femur		Large bowel surgery		Spinal surgery		Coronary artery bypass graft	
	Reported causative organism	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Monomicrobial	Methicillin-sensitive *S.aureus*	148	30.0	182	38.6	95	25.2	4	2.5	89	38.5	53	27.0
	Methicillin-resistant *S.aureus*	20	4.1	17	3.6	33	8.8	3	1.9	6	2.6	7	3.6
	Coagulase-negative staphylococci	125	25.4	118	25.1	75	19.9	5	3.2	57	24.7	44	22.4
	Enterobacteriaceae	105	21.3	53	11.3	102	27.1	93	59.2	44	19.0	61	31.1
	Pseudomonas	10	2.0	12	2.5	15	4.0	7	4.5	10	4.3	16	8.2
	Streptococcus	35	7.1	38	8.1	10	2.7	6	3.8	7	3.0	2	1.0
	Enterococcus	26	5.3	18	3.8	27	7.2	12	7.6	6	2.6	3	1.5
	Other bacteria	23	4.7	32	6.8	18	4.8	22	14.0	11	4.8	10	5.1
	Fungi including *Candida* spp.	1	0.2	1	0.2	2	0.5	5	3.2	1	0.4	0	0.0
	Total monomicrobial	**493**	**100**	**471**	**100**	**377**	**100**	**157**	**100**	**231**	**100**	**196**	**100**
Polymicrobial	Gram-positive combinations only	108	43.9	64	44.8	69	31.2	5	3.1	44	57.9	37	21.8
	Gram-negative combinations only	28	11.4	15	10.5	29	13.1	35	22.0	8	10.5	43	25.3
	Gram-positive and Gram-negative combinations	101	41.1	58	40.6	105	47.5	77	48.4	20	26.3	71	41.8
	Other	9	3.7	6	4.2	18	8.1	42	26.4	4	5.3	19	11.2
	Total polymicrobial	**246**	**100**	**143**	**100**	**221**	**100**	**159**	**100**	**76**	**100**	**170**	**100**
	Total cases**	**739**	**100**	**614**	**100**	**598**	**100**	**316**	**100**	**307**	**100**	**366**	**100**

Notes
* surgical categories with ≥ 100 cases with available microbiology information were included.
**total cases for analyses refer to those with available microbiology information.

Hospital perspectives

Insights from peers provide an opportunity for hospitals to share and learn from each other. The following were submitted by hospitals and reflect their own perspectives and learning from carrying out surveillance or undertaking new quality improvement initiatives over the past financial year.

The importance of the multidisciplinary team in the reduction of SSI at the Royal Devon & Exeter Hospital

At the RD&E hospital, SSI surveillance plays a key role in unifying the multidisciplinary team to work towards the common goal of SSI reduction.

In 2017/18 we were able to conduct continuous SSI surveillance in the hip, knee, spinal and breast surgical categories. We are fortunate to have a dedicated surveillance team which affords us the ability to strive towards the PHE SSISS desire for robust methodology and consistency with definition application. We are encouraged to engage with all members of the multidisciplinary team in order to achieve unity in our approach towards infection surveillance and SSI reduction.

Over the years, through continuous SSI surveillance, feedback and review, this has led to multiple evidence-based changes in practice. SSI surveillance has been a valuable mechanism through which those discussions about SSI reduction, locally agreed care pathways and the implementation of best practice interventions has been able to occur. This ranges from the creation of regular, speciality consultant driven, multidisciplinary SSI case review team meetings, to the increasing recognition of the importance of routine ward-based SSI surveillance which affords multiple opportunities to deploy effective preventative SSI strategies and feedback health promotion opportunities not only to staff but also patients and their carers.

Melanie Thornton, Infection Surveillance Specialist Nurse
Royal Devon & Exeter NHS Foundation Trust

Reducing SSI risk through a new quality initiative at Harefield Hospital

Harefield Hospital has consistently participated in the PHE scheme for CABG since 2003 and general cardiac since 2010. In 2018, we requested PHE review of SSI readmission trends to examine the impact of our Photo at Discharge (PaD) initiative.

PHE kindly supplied aggregate data on SSI readmissions for the CABG and Cardiac Module 2011 to 2017, with data collected ranging from 17 to 22 hospitals per year. The combined SSI readmission rate was 1% (standard deviation 0.77-1.03) for the period. In 2014, although overall our SSI rate was low, our SSI readmission rate was 1.1%. This was above the national average. We worked with patients and the multidisciplinary team to create PaD, a simple idea to improve patient self-management and monitoring with a colour photo and accompanying assessment.

Following the introduction of PaD, our SSI readmission rate has steadily fallen. Over the last year, data from PHE suggests our combined SSI readmission rate is 0.3%, thus an estimated 70% lower than the combined national benchmark for SSI readmission.

In 2017, our hospital received several low outlier notifications from PHE. We have important re-assurance concerning all our wounds, because we have colour records of all surgical wounds via PaD and the WoundCare1 ([W1] software for wound assessment, care planning and reporting, developed in collaboration with the Royal College of Nursing). We feel the PaD and W1 contributes significantly to an active SSI surveillance scheme and avoids the pitfalls associated with passive surveillance, such as under-identification of SSI.

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Reducing SSI in hip fracture patients at St.Peter's Hospital, Surrey: a marginal gains approach

SSI rates for fractured neck of femur at St.Peter's Hospital have been double the national benchmark with rates varying from 2.5-5.5% over the past 4 years surveillance. In response to this, a multidisciplinary team was formed to drive a quality improvement (QI) project.

Using QI methodology, we adopted a Marginal Gains approach to improve care across the patient pathway. We targeted 13 areas pre-, intra- and post-operatively with audit and multiple specific evidence-based improvements. These included pre-op washes and carbohydrate drinks, new warming blankets pre-, intra- and post-operatively, monitored adherence to the surgical safety checklist, tranexamic acid to reduce bleeding, and standardizing both theatre temperature and surgical practice. Post-operatively, we used restrictive transfusion and adopted an oozy wound protocol.

We demonstrated improvement including reduction in hypothermia from 44% to 3%, increased tranexamic acid use from 35% to 75% and reduced blood transfusion rate from 28% to 18%. Following implementation of these improvements, we went 257 days without SSI and for the last 298 fractured neck of femur patients, our inpatient/readmission infection rate has fallen to 0.3%.

We feel the key to this project was attention to detail, multidisciplinary involvement and improvements across multiple aspects of care – the so called Marginal Gains approach.

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Discussion

Summary

Overall, a total of 201 NHS hospitals representing 142 NHS trusts and an additional 8 IS NHS treatment centres participated in the SSISS in 2017/18 (all surgical categories). The total number of procedures submitted to SSISS in 2017/18 decreased by 4% compared to 2016/17. In 2017/18, the largest decreases in submissions for the voluntary surgical categories were bile duct, liver or pancreatic surgery (73% decrease) and large and small bowel surgery (both 37% decrease). The largest increases in submissions for voluntary surgical categories were abdominal hysterectomy (30% increase) and cardiac (non-CABG) surgery (12% increase). Fewer hospitals were identified as outliers for the mandatory orthopaedic categories in 2017/18 compared to previous years with SSI risk results showing less variation in general. Larger variations in SSI risk were evident for other categories of surgery suggesting more could be done to reduce SSI risk in some hospitals.

Trends in the SSI incidence showed a variable picture between surgical categories. The incidence of SSI following hip and knee replacement saw further decreases in 2017/18. SSI risk following knee replacement is slightly lower than hip replacement, also seen in other European countries [8].

Large bowel surgery showed the greatest variability in SSI risk among hospitals. Sharing of best practice between units may help, with SSISS facilitating this where requested.

The ongoing reductions observed in MRSA reflect the impact of infection control initiatives directed at controlling MRSA, such as pre-admission screening and decolonisation of carriers [9]. Results suggest that these types of preventative measures remain important. The increasing prevalence of Gram-negative bacteria, particularly Enterobacteriaceae remains a concern. Accounting for 28.6% of SSIs in 2016/17 this continued to increase in 2017/18 to 30.8%. As part of efforts to tackle the threat to public health posed by antimicrobial resistance (AMR), the UK government pledged in 2016 to reduce the number of healthcare-associated Gram-negative bloodstream infections in England by 50% by March 2020 [10]. The proportion of CoNS-attributed SSIs has been gradually increasing since 2009/10 and should be further explored.

Future directions

Stakeholder feedback into SSISS remains essential to shape the future delivery of surveillance and ensure we meet hospitals' evolving requirements. In March 2018 we sent a survey to all SSISS registered hospitals. In an effort to continue to engage stakeholders and identify areas for improvement for the service going forward, users were asked to provide feedback on the following: data validation and submission process, outlier identification and support, and hospital reports and local action.

A total of 124 responses (74 NHS and 50 independent sector providers) were submitted. The majority of hospitals reported being satisfied or very satisfied with the data validation quality assurance process (88%). There was also general satisfaction with the content, clarity and style of outlier letters received. The content of the low outlier letters however, were marked slightly less favourably than high outlier letters. 64% of respondents considered national benchmarking useful or very useful and importantly 69% of NHS respondents indicated taking action as a result of participating in the programme. In terms of reporting, the majority of respondents (75%) said they had downloaded a hospital summary or user-defined report in the last year to view and discuss their results further. There were still 25% of respondents however, who did not access their web-based reports in the last year, despite SSISS recommendations to examine quarterly summary reports at the end of each surveillance period. When asked about the usefulness of these reports, 80% of respondents rated them as "very useful" or "useful". Respondents felt the reports could be clearer and more user-friendly. Interactive graphs with advanced functionality for tailored comparisons and various level reporting (ie trust, region) were of importance.

The redesign of the hospital web-based reports is something that will be achievable with the launch of the new enhanced web application in 2019 and has been placed as a key priority following this.

Other feedback we received focused on increased opportunities for sharing and networking across hospitals and comparing to peers. Some of these additional comparators are being made available through PHE's public reporting tool, Fingertips (fingertips.phe.org.uk/profile/amr-local-indicators). Trust-level SSI risk following hip replacement and knee replacement results are available in the tool from 2014/15 onwards. The tool now allows users to further group results by trust type (ie teaching, non-teaching, and specialty) or NHS sub-region and compare to a corresponding overall average. Looking ahead, we hope to expand on the increased interest in further allowing hospital to make tailored peer comparisons.

The development of an electronic version of the patient post-discharge questionnaire (ePDQ) continues to progress and has successfully completed its alpha phase of digital development in 2018. The electronic PDQs will improve ease of use for hospitals and enhance the completeness and timeliness of PDQ returns. With improved uptake and quality of optional post-discharge surveillance we hope to be able to use this data for national benchmarking.

With advancements in data integration capabilities, the team is also beginning discussions with NHS Digital to identify potential opportunities for enhancing data collection. This could reduce the burden of surveillance data collection for hospital staff.

Glossary

ASA score
Patient's pre-operative physical status scored by the anaesthetist according to the American Society of Anaesthesiologists' classification of physical status. There are 5 ASA scores, ranging from A1 denoting normally healthy patient to A5 denoting moribund patient with little chance of survival.

Confidence intervals
Confidence intervals are used to show where the true range of results lie. 95% confidence intervals are used throughout to provide a guide to the precision of the estimate based on the number of procedures (or days of follow-up) carried out by the participating hospital. A 95% confidence interval can also be interpreted as "there is a 1 in 20 chance that the observed estimate is due to chance alone". The funnel plots use both 95% and 99% confidence limits to represent the limits of expected variation among trusts and establish a threshold for "warning" of an unexpected result and needing to take "action". A 99% confidence range is wider but is offset with a lower margin of error (1%).

Cumulative incidence
The total number of SSIs as a proportion of the total number of patients undergoing a procedure in the same category of surgery per 100 procedures (%).

Incidence density
The total number of SSIs (identified through inpatient surveillance) divided by the total number of days of inpatient follow-up expressed as the number of SSIs per 1,000 days of patient follow-up.

Independent sector NHS treatment centres
Centres that provide services to NHS patients but are owned and run by organisations outside the NHS. They perform common elective (ie non-emergency) surgeries, diagnostic procedures and tests in an effort to help the NHS reduce waiting times.

NHSN Risk Index
The CDC National Healthcare Safety Network (NHSN) Risk Index assesses a patient's risk of developing an SSI based on the presence of 3 key risk factors (ASA score, surgery duration, and wound class). Patients are assigned a cumulative score from 0 to 3 based on the following: an ASA score of 3 or more, duration of surgery exceeding the 75^{th} percentile, and a contaminated or dirty wound class. A patient with a score of 3 would indicate high risk.

T time

T time represents the expected duration for a particular surgical procedure based on the 75th percentile for the duration of all such procedures, rounded to the nearest hour. T times for all surgical categories are as follows:

Surgical category	T Time (hours)
Abdominal hysterectomy	2
Bile duct, liver, or pancreatic surgery	5
Breast surgery	3
Cholecystectomy	2
Cardiac surgery (non-CABG)	5
Coronary artery bypass graft	5
Cranial surgery	4
Gastric surgery	3
Hip replacement	2
Knee replacement	2
Large bowel surgery	3
Limb amputation	1
Reduction of long bone fracture	2
Repair of neck of femur	1.5*
Small bowel surgery	3
Spinal surgery	3
Vascular surgery	3

**T time derived from SSISS data.*

Wound class

This describes the degree of wound contamination at the time of the operation, based on an international standard classification system. The classification ranges from W1 denoting a clean uninfected wound outside the respiratory, alimentary, and genital or urinary tract to W4 denoting dirty or infected wounds and include operations in which acute inflammation with pus is encountered or in which perforated viscera are found.

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Appendix A

Requirements for data fields that inform patient and surgery-related characteristics:

Characteristic	Requirement
Patient age	Calculated from mandatory date of birth and date of operation data fields
Patient sex	Mandated for submission, however “unknown” is an available response option
Patient BMI	Calculated from optional height and weight data fields
Patient ASA score	Mandated for submission, however “unknown” is an available response option
Wound class	Mandated for submission, however “unknown” is an available response option
Operation duration	Mandated for submission
Pre-operative stay	Calculated from mandatory date of admission and date of operation data fields
Elective surgery	Mandated for submission, however “missing” is an available response option
Trauma surgery	Mandated for submission, however “missing” is an available response option
Primary indication for surgery	Mandated for submission, however “unknown” is an available response option
Antibiotic prophylaxis given	Mandated for submission, however “unknown” is an available response option