Surveillance of surgical site infections in NHS hospitals in England

April 2016 to March 2017

December 2017
Public Health England exists to protect and improve the nation’s health and wellbeing, and reduce health inequalities. We do this through world-leading science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health, and a distinct delivery organisation with operational autonomy to advise and support government, local authorities and the NHS in a professionally independent manner.
Acknowledgement

We are grateful to the administrative staff at PHE’s Surgical Site Infection Surveillance Service, staff within the PHE Software Development Unit and the considerable contribution made by NHS trusts in England who have devoted time and effort in collecting these data. Finally, special thanks are extended to hospitals who shared their experience of the SSI surveillance for inclusion in this report.

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Suggested citation

Key points

In April 2016 to March 2017, data on 139,691 procedures and 1,635 surgical site infections (SSIs) detected during the inpatient stay or on readmission following the initial operation were collected by 201 NHS hospitals and 8 independent sector NHS treatment centres for 17 surgical categories under surveillance.

The cumulative SSI incidence (data from April 2012 to March 2017) ranged from 9.2% in large bowel surgery to <1% in hip and knee prosthesis.

11 NHS trusts were identified as high outliers for the mandatory orthopaedic categories in April 2016 to March 2017 having an SSI incidence higher than expected. Six NHS trusts and two NHS treatment centres were identified as low outliers in April 2016 to March 2017. All 19 providers have been contacted and asked to investigate possible reasons.

The highest SSI risk within hip prosthesis in April 2016 to March 2017 was for surgery to treat avascular necrosis (1.7%), which exceeded the SSI risk for revision surgery. In knee prosthesis, the SSI risk was highest for revision surgery to treat fracture (5.1%).

A significant decrease in SSIs occurred between April 2009 to March 2010 and April 2016 to March 2017 in repair of neck of femur (from 1.6% to 1.0%) and for reduction of long bone fracture (from 1.5% to 0.7%).

The SSI incidence remained low for hip and knee prosthesis (<1%) with stable trends in both surgical categories in the last 3 successive years.

A significant decrease in SSI occurred for coronary artery bypass graft (CABG) surgery, from 5.7% in April 2009 to March 2010 to 3.8% in April 2016 to March 2017.

Spinal surgery showed a significant increase in SSI from 0.9% in 2009 to 10 to 1.4% in April 2016 to March 2017 as did cholecystectomy (from 0.9% to 3.0%) over the same period; the increase in SSI in cardiac non-CABG surgery (from 1.0% to 1.7%) reached borderline significance.

Enterobacteriaceae continued to increase, accounting for 29% of SSIs in April 2016 to March 2017, the highest to date. *Staphylococcus aureus* and the methicillin-resistant form (MRSA) continued to decrease accounting for 11% and 2% of inpatient-detected SSIs in April 2016 to March 2017 respectively. Small, steady decreases in methicillin-susceptible *S. aureus* (MSSA) were observed since April 2013 to March 2014, stabilising at 9% of SSIs in 2015 to 2016 and April 2016 to March 2017.
Using 3-year data to Apr 2016 to Mar 2017, Enterobacteriaceae were the predominant causes of SSIs in large bowel (53%) and CABG surgery (29%), the latter increasing from 26% based on 3-year data to 2015 to 2016.

*S. aureus* was the predominant cause of SSI in orthopaedic and spinal surgery (≥33% of cases), with a small decrease in repair of neck of femur (to 41%, data to Apr 2016 to Mar 2017); coagulase-negative staphylococci (CoNS) were still predominant in CABG SSIs (26%) although CoNS in spinal surgery exceeded that seen in CABG for the first time (28%).

In primary total hip prosthesis, the proportion of SSIs due to *S. aureus* was highest in the uncemented (44%) compared to the cemented (35%) and hybrid fixation (31%) groups.
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1. Introduction and surveillance methods

1.1 Introduction

This report is a summary of data on surgical site infections (SSIs) collected by NHS hospitals and independent sector (IS) NHS treatment centres in England participating in one of 17 surgical categories of surveillance between April 2004 and March 2017. The results include orthopaedic data submitted by hospitals following the mandatory surveillance requirement introduced by the Department of Health in April 2004 [1]. This requires all NHS trusts undertaking orthopaedic surgical procedures to carry out a minimum of 3 months’ surveillance in each financial year in at least one of four categories (hip prosthesis, knee prosthesis, repair of neck of femur or reduction of long bone fracture). Trusts with very small volumes are exempt from the mandatory surveillance but are expected to undertake surveillance in a category that reflects the largest component of their surgical activity.

In response to the Competitions and Market Authority (CMA) order in 2014, all independent sector hospitals have been required to provide specified patient outcome data including SSIs from September 2016 and to publish results from April 2017 on the web-site of the CMA-nominated information organisation [2].

1.2 Data collection and feedback

To participate in PHE’s national SSI surveillance programme, hospitals must first attend training at the national co-ordinating centre in London. Once trained, all participating hospitals are required to follow the surveillance protocol outlining the case definitions and follow-up methods [3]. Surveillance data are collected prospectively on all eligible patients in a surgical category on a quarterly basis (3 months). Patients are followed-up to identify SSIs for 30 days after surgery for non-implant procedures and one year for prosthetic implant procedures. Demographic and operation-related data are collected for each eligible procedure and submitted via a secure web-based application.

Since July 2008, hospitals are required to have systems in place to track patients included in the surveillance but later readmitted hospital with an SSI. SSIs identified on readmission are assigned to the hospital where the original operation took place. Other post-discharge surveillance methods were introduced in 2008 but remain optional. They are: a) systematic review of patients attending outpatient clinics or at home by clinical staff trained to apply the case definitions and b) wound healing questionnaires completed by patients 30 days after the operation [3]. SSIs captured from these optional methods are not currently included in the national benchmarks or outlier assessments.
After each completed quarter, participating hospitals can download automated confidential reports accessed securely from the SSI web application for dissemination within their trust. These reports provide the hospitals’ crude SSI incidence and the corresponding national benchmark by surgical category. A range of web-based reports are available which include data stratified by risk factors and data quality indicators.

PHE analyses the submitted data at quarterly intervals to identify hospitals whose SSI incidence falls above the national 90th or below the 10th percentiles for each surgical category. PHE alerts these hospitals of their outlier status and encourages them to investigate possible reasons. Additional support is provided to hospitals who request advice or in-depth epidemiological analysis to assist with investigating persistent SSI problems. On-site visits are offered by PHE as a vehicle for sharing in-depth analyses and further surveillance advice to multi-disciplinary teams.

1.3 Definitions

SSIs are defined according to a standard set of 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) [4] 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 two symptoms to accompany a clinical diagnosis (superficial SSIs only).

A range of risk factors are captured through the surveillance including the American Society of Anesthesiologists (ASA) score. This is the patient’s pre-operative physical status on a scale from 1 to 5, with higher scores indicating severe systemic disease. An ASA score of 3 or more, along with the category-specific T-time (duration of surgery exceeding the >75th percentile rounded to the nearest hour) and a contaminated or dirty wound class constitute the three elements of the CDC National Healthcare Safety Network (NHSN) Risk Index [5]. There are four wound contamination classes (clean, clean-contaminated, contaminated and dirty) each with accepted standard definitions [3;4;6]

1.4 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 [6]. As data are anonymised, they cannot be traced back to individual patients, surgeons or named hospitals. 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, however, may be affected by differences in surveillance methodology and/or risk factors. A recent comparison of SSI data between England and Norway identified differences in the SSI incidence for selected surgical categories due to differences in surveillance methodology and risk factors [7].

1.5 Analyses presented in this report

Data on surgical procedures carried out between April 2004 and March 2017 collected by NHS hospitals and independent sector NHS treatment centres were extracted on 17 October 2017 for this report. The SSIs included in this report are based on cases detected during the inpatient stay or on readmission following the initial operation. Data from 2004 were used for showing secular trends in inpatient-detected SSI incidence. SSI trends from April 2009 onwards were evaluated as this provided full financial years with required readmission data (readmission surveillance became a requirement from July 2008 for all participating hospitals, being optional prior to July 2008).

For benchmarking purposes, cumulative 5-year data were used (April 2012 to March 2017).

Where appropriate, inpatient SSIs were analysed separately for meaningful interpretation. To take into account the variation in the length of follow-up, the incidence density (ID) was calculated using the number of cases as the numerator and the total number of days of inpatient follow-up as the denominator, expressed as the number of SSIs per 1,000 patient days of follow-up. The exact binomial 95% confidence interval (CI) for proportions and Poisson CI for the ID are given in this report.

Organism data for SSIs are also presented in this report. Participating hospitals can submit data on up to three causative organisms based on clinically significant isolates.

Annual orthopaedic data from participating hospitals are aggregated to trust level for public reporting purposes. Funnel plots were constructed for each mandatory orthopaedic category using the cumulative inpatient/readmission SSI incidence by NHS trust. Each plot identifies trusts that fall within the expected variation and trusts that are outliers (incidence falling beyond the upper or lower 95% control limits). Independent sector NHS treatment centres are included in these plots. An additional supplement to this report contains the Apr 2016 to Mar 2017 SSI incidence by NHS trust and orthopaedic category: https://www.gov.uk/government/publications/surgical-site-infections-ssi-surveillance-nhs-hospitals-in-england
2. Overview

2.1 Hospital participation and surgical volumes

Overall, a total of 201 NHS hospitals representing 142 NHS trusts and an additional 8 Independent Sector (IS) NHS treatment centres participated in Apr 2016 to Mar 2017, contributing data on 139,691 procedures and 1,635 inpatient/readmission SSIs for 17 surgical categories. This compares with 136,875 procedures and 1,651 inpatient/readmission SSIs in 2015 to 2016 collected by 198 NHS hospitals representing 142 trusts and an additional 7 IS NHS treatment centres.

Figure 1 shows trends in hospital participation and surgical volume in the national SSI surveillance scheme split by the mandatory orthopaedic and the voluntary non-orthopaedic modules. In Apr 2016 to Mar 2017, 187 NHS hospitals representing 137 NHS trusts participated in the orthopaedic surveillance along with 8 IS NHS treatment centres, the combined total (n=195) slightly exceeding that for Apr 2015 to Mar 2016 (n=191). There was a 4% increase in orthopaedic surgery volume between Apr 2015 to Mar 2016 and Apr 2016 to Mar 2017 (n=103,841 and n=108,402 and respectively). Three eligible NHS trusts did not participate in the mandatory orthopaedic surveillance in Apr 2016 to Mar 2017. Of the 137 NHS trusts that participated in the mandatory orthopaedic surveillance in Apr 2016 to Mar 2017, 87% (n=119) fulfilled more than the minimum requirement (one surveillance category for 3 months).

For the voluntary non-orthopaedic categories, total surgical volume decreased by 5% between Apr 2015 to Mar 2016 (n=33,034) and Apr 2016 to Mar 2017 (n=31,289). The number of participating hospitals also decreased slightly from 72 to 69 hospitals.

Figure 1: Trends in the number of NHS hospitals participating in the SSI Surveillance Service and procedures submitted, England
Figure 2 shows the trends in continuous surveillance in the mandatory orthopaedic categories. There has been a general increase across all surgical categories over time. In Apr 2016 to Mar 2017, the proportion of hospitals undertaking continuous surveillance increased to 62% in both hip and knee prosthesis compared to 59% and 60% respectively in 2015 to 2016. Continuous surveillance also increased for repair of neck of femur to 50% compared to 45% in the previous year. Continuous participation decreased to 44% for reduction of long bone fracture (47% in 2015 to 2016).

Of the 12 remaining surgical categories, 6 were excluded from the analysis of continuous surveillance on the basis of having <10 participating hospitals in Apr 2016 to Mar 2017. The remaining 6 that were included - coronary artery bypass graft (CABG), cardiac non-CABG, spinal, large bowel, small bowel and breast surgery - showed considerable variation in the proportion of hospitals undertaking continuous surveillance (57%, 80%, 50%, 39%, 29%, and 28% respectively). Of these 6 categories, only CABG, cardiac (non-CABG) and breast surgery had an increasing number of hospitals undertaking continuous surveillance (compared to 40%, 46% and 24% respectively in Apr 2015 to Mar 2016). The remaining 4 categories (large bowel, small bowel and spinal surgery) showed a decrease compared to Apr 2015 to Mar 2016. The results for the voluntary categories may partly reflect inter-year variation in the set of participating hospitals.

Figure 2: Trends in the proportion of hospitals undertaking continuous surveillance, by orthopaedic category, NHS hospitals, England

2.3 Data quality

Data completion for key SSI risk factors is essential for risk stratification purposes, enabling hospitals to use that information to identify possible reasons underpinning unusual deviations from the SSI national benchmark or from previous local trends.
Table 1 shows the proportion of records submitted with completed fields for key data items by surgical category during Apr 2016 to Mar 2017.

Nationally, data completion for age, patient sex, date of admission and procedure code remained at 100% for records submitted in Apr 2016 to Mar 2017 across all surgical categories. For the risk factors used in the NHSN risk index (see section 1), data completion was very high (≥99%) for wound class and duration of surgery across most surgical categories although for ASA score there was more variation, ranging between 73% for cardiac (non-CABG) surgery and 99% for bile duct/liver/pancreatic surgery.

In Apr 2016 to Mar 2017, the proportion of participating hospitals that provided ASA score data in 95% or more of their submitted records was highest in bile duct/liver/pancreatic surgery and cholecystectomy (100% each). This was next highest in abdominal hysterectomy, knee prosthesis, vascular, hip prosthesis, and cardiac non-CABG (83%, 81%, 78%, 77% and 70% respectively).

Table 1: Percentage of submitted surveillance records with complete data for key data items, NHS hospitals in England, Apr 2016 to Mar 2017

<table>
<thead>
<tr>
<th>Surgical Category</th>
<th>Total No. operations</th>
<th>Age</th>
<th>ASA score</th>
<th>Duration of operation</th>
<th>Wound class</th>
<th>Patient sex</th>
<th>Date of admission</th>
<th>OPCS code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal hysterectomy</td>
<td>462</td>
<td>100</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>40</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Bile duct, liver or pancreatic surgery</td>
<td>495</td>
<td>100</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>61</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Breast surgery</td>
<td>4,071</td>
<td>100</td>
<td>93</td>
<td>100</td>
<td>100</td>
<td>36</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Cardiac (non-CABG)</td>
<td>3,664</td>
<td>100</td>
<td>73</td>
<td>100</td>
<td>100</td>
<td>92</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>336</td>
<td>100</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>81</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>6,205</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>84</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Cranial surgery</td>
<td>1,894</td>
<td>100</td>
<td>86</td>
<td>100</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Gastric</td>
<td>437</td>
<td>100</td>
<td>84</td>
<td>100</td>
<td>99</td>
<td>22</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Hip replacement</td>
<td>41,724</td>
<td>100</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>60</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Knee replacement</td>
<td>44,937</td>
<td>100</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Large bowel surgery</td>
<td>4,242</td>
<td>100</td>
<td>94</td>
<td>100</td>
<td>100</td>
<td>59</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Limb amputation</td>
<td>344</td>
<td>100</td>
<td>78</td>
<td>100</td>
<td>98</td>
<td>12</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Reduction long bone fracture</td>
<td>2,171</td>
<td>100</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>16</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Repair of neck of femur</td>
<td>19,570</td>
<td>100</td>
<td>93</td>
<td>100</td>
<td>100</td>
<td>25</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Small bowel surgery</td>
<td>1,103</td>
<td>100</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>46</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Spinal surgery</td>
<td>6,741</td>
<td>100</td>
<td>86</td>
<td>98</td>
<td>98</td>
<td>37</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>1,295</td>
<td>100</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>34</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*patients ≥16 years

Data completeness was considerably lower for height and weight used to calculate body mass index (BMI), ranging from 12% in limb amputation to 92% for cardiac (non-CABG) surgery.

In Apr 2016 to Mar 2017, 8 surgical categories had BMI data completion of 50% or more of submitted records (cardiac non-CABG, CABG, cholecystectomy, cranial, knee prosthesis, bile duct/liver/pancreatic, hip prosthesis and large bowel surgery) (Table 1).
In Apr 2016 to Mar 2017, BMI data completion increased in 11 surgical categories compared to Apr 2015 to Mar 2016. The biggest increase was in cardiac non-CABG surgery (from 79% in Apr 2015 to Mar 2016 to 92% in Apr 2016 to Mar 2017) followed by hip prosthesis (from 55% in Apr 2015 to Mar 2016 to 60% in Apr 2016 to Mar 2017). This also increased for knee prosthesis from 60% to 65% over the same period. For the remaining 6 surgical categories, BMI data completion decreased with the biggest decrease in breast surgery (from 51% in Apr 2015 to Mar 2016 to 36% in Apr 2016 to Mar 2017).

The proportion of participating hospitals achieving BMI data completion in ≥50% of their submitted records in Apr 2016 to Mar 2017 was highest in CABG, cardiac non-CABG, bile duct/liver/pancreatic and cranial surgery (93%, 90%, 75% and 71% respectively). The lowest proportion was seen in reduction of long bone fracture with 28% of hospitals achieving ≥50% data completion.

2.4 Patient and operation-related characteristics

Patient and operation-related characteristics derived from surveillance records for patients undergoing surgery in Apr 2016 to Mar 2017 are shown in Tables 2 and 3.

The median age varied by surgical category (Table 2) being lowest in abdominal hysterectomy (49 years) and highest in repair of neck of femur (85 years). Duration of operation was highest in both cardiac categories (CABG and cardiac non-CABG), each having median duration in excess of 200 minutes. The categories of surgery with the highest proportion of patients with an ASA score ≥3 were in CABG and cardiac categories (>90% each) and in limb amputation surgery (80%). Small bowel, limb amputation and large bowel surgery had the highest proportion of procedures with a wound classified as contaminated or dirty (48% and 18% for the latter two respectively).

Of 8 surgical categories with BMI data completion of 50% or more (cardiac non-CABG, CABG, cholecystectomy, cranial, knee prosthesis, bile duct/liver/pancreatic, hip prosthesis and large bowel surgery, see Table 1), knee prosthesis and cholecystectomy had the highest proportion of patients (56% and 49% respectively) classed as obese (BMI ≥ 30kg/m²). All of these 8 surgical categories had BMI data completion of 50% or more in Apr 2015 to Mar 2016 and of these, obesity levels increased in 5 categories in Apr 2016 to Mar 2017 with bile duct/liver/pancreatic surgery and cholecystectomy having the biggest increase compared to Apr 2015 to Mar 2016 (from 39% to 44% and from 45% to 49% of patients being obese respectively). For the remaining 3 surgical categories obesity levels remained similar to the previous year.

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 small bowel and vascular surgery (9% and 6%
respectively). Although repair of neck of femur patients are usually admitted on an emergency basis, the proportion classified as emergency procedures based on the PHE surveillance definitions was <0.5%.

The proportion of patients receiving surgical antimicrobial prophylaxis was high (≥95%) in 11 surgical categories including the orthopaedic categories, reflecting the current recommendations aimed at defined surgical groups [8;9]. The highest proportion was in hip and knee replacement (99.5% each) and the lowest recorded was in cholecystectomy (37%).

The proportion of patients where discontinuation of inpatient surveillance was due to death was highest in repair of neck of femur and vascular surgery in Apr 2016 to Mar 2017 (6% and 4%, respectively). These should be interpreted with caution as these data only capture deaths within the inpatient stay.

Table 3 shows primary indication for surgery in patients undergoing hip and knee prosthesis surgery. In hip and knee prosthesis, osteoarthritis accounted for the majority of procedures (82% and 92%, respectively). The second most common indication was revision (9% and 6%, respectively).
### Table 2: Patient and operation-related characteristics by surgical category, NHS hospitals, England, Apr 2016 to Mar 2017

<table>
<thead>
<tr>
<th>Surgical Category</th>
<th>Median Age in years (IQR)</th>
<th>Median Duration Operation in Minutes (IQR)</th>
<th>Median Length Hospital Stay in Days (IQR)</th>
<th>ASA ≥ 3 (%)</th>
<th>Contaminated/dirty Incision (%)</th>
<th>BMI ≥ 30 (%)</th>
<th>Male (%)</th>
<th>Emergency (%)</th>
<th>Revision (%)</th>
<th>Antibiotic Prophylaxis (%)</th>
<th>Implant (%)</th>
<th>Inpatient Surveillance Discontinued due to Death (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal hysterectomy</td>
<td>49 (44-59)</td>
<td>106 (90-140)</td>
<td>2 (2-4)</td>
<td>13.0</td>
<td>0.4</td>
<td>46.2</td>
<td>N/A</td>
<td>0.6</td>
<td>0.2</td>
<td>98.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Bile duct, liver or pancreatic surgery</td>
<td>60 (46-70)</td>
<td>148 (84-300)</td>
<td>4 (1-7)</td>
<td>25.7</td>
<td>3.4</td>
<td>43.7</td>
<td>41.4</td>
<td>2.2</td>
<td>0.2</td>
<td>94.2</td>
<td>0.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Breast surgery</td>
<td>57 (47-69)</td>
<td>67 (41-99)</td>
<td>1 (1-1)</td>
<td>10.8</td>
<td>0.1</td>
<td>29.8</td>
<td>2.2</td>
<td>0.1</td>
<td>2.0</td>
<td>77.9</td>
<td>12.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td>66 (49-75)</td>
<td>240 (192-300)</td>
<td>8 (6-13)</td>
<td>89.5</td>
<td>0.1</td>
<td>29.5</td>
<td>63.0</td>
<td>1.5</td>
<td>2.6</td>
<td>99.0</td>
<td>85.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>51 (38-65)</td>
<td>70 (57-87)</td>
<td>1 (1-1)</td>
<td>7.7</td>
<td>0.0</td>
<td>48.7</td>
<td>26.2</td>
<td>0.9</td>
<td>N/A</td>
<td>37.2</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Coronary artery bypass graft surgery</td>
<td>69 (61-75)</td>
<td>230 (193-270)</td>
<td>6 (5-9)</td>
<td>92.9</td>
<td>0.0</td>
<td>34.2</td>
<td>81.9</td>
<td>1.1</td>
<td>0.2</td>
<td>99.2</td>
<td>70.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Cranial surgery</td>
<td>57 (43-69)</td>
<td>120 (64-205)</td>
<td>5 (3-10)</td>
<td>39.4</td>
<td>1.5</td>
<td>26.6</td>
<td>54.8</td>
<td>4.2</td>
<td>0.1</td>
<td>98.2</td>
<td>56.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Gastric surgery</td>
<td>60 (48-70)</td>
<td>160 (100-321)</td>
<td>5 (2-9)</td>
<td>35.0</td>
<td>4.2</td>
<td>33.7</td>
<td>48.5</td>
<td>0.9</td>
<td>2.7</td>
<td>98.6</td>
<td>4.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Hip replacement</td>
<td>71 (62-78)</td>
<td>84 (66-105)</td>
<td>4 (3-6)</td>
<td>23.4</td>
<td>0.1</td>
<td>38.7</td>
<td>39.6</td>
<td>0.0</td>
<td>9.1</td>
<td>99.5</td>
<td>100.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Knee replacement</td>
<td>70 (63-77)</td>
<td>78 (62-98)</td>
<td>4 (3-5)</td>
<td>21.9</td>
<td>0.0</td>
<td>55.8</td>
<td>42.8</td>
<td>0.0</td>
<td>5.4</td>
<td>99.5</td>
<td>100.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Large bowel surgery</td>
<td>69 (57-77)</td>
<td>170 (120-231)</td>
<td>7 (5-13)</td>
<td>39.8</td>
<td>17.9</td>
<td>24.9</td>
<td>51.9</td>
<td>5.0</td>
<td>N/A</td>
<td>98.0</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Limb amputation</td>
<td>69 (56-78)</td>
<td>51 (32-80)</td>
<td>7 (1-6)</td>
<td>79.6</td>
<td>18.0</td>
<td>10.0</td>
<td>72.0</td>
<td>2.9</td>
<td>N/A</td>
<td>86.6</td>
<td>0.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Reduction of long bone fracture</td>
<td>63 (41-78)</td>
<td>90 (63-120)</td>
<td>4 (1-12)</td>
<td>33.7</td>
<td>2.8</td>
<td>15.9</td>
<td>39.4</td>
<td>0.2</td>
<td>N/A</td>
<td>99.1</td>
<td>99.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Repair of neck of femur</td>
<td>85 (78-90)</td>
<td>66 (51-89)</td>
<td>13 (8-21)</td>
<td>73.6</td>
<td>0.0</td>
<td>9.8</td>
<td>30.5</td>
<td>0.3</td>
<td>0.3</td>
<td>98.0</td>
<td>100.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Small bowel surgery</td>
<td>61 (45-72)</td>
<td>120 (75-200)</td>
<td>8 (5-15)</td>
<td>40.6</td>
<td>48.0</td>
<td>20.8</td>
<td>53.4</td>
<td>9.1</td>
<td>0.5</td>
<td>94.9</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Spinal surgery</td>
<td>54 (39-68)</td>
<td>132 (90-193)</td>
<td>3 (1-7)</td>
<td>23.1</td>
<td>0.3</td>
<td>34.0</td>
<td>47.0</td>
<td>0.2</td>
<td>34.4</td>
<td>99.3</td>
<td>52.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>73 (66-80)</td>
<td>175 (127-237)</td>
<td>3 (2-7)</td>
<td>77.0</td>
<td>0.5</td>
<td>20.7</td>
<td>71.0</td>
<td>5.6</td>
<td>0.0</td>
<td>89.0</td>
<td>69.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*patients ≥16 years; †N/A indicates no revision surgery included in the category under surveillance

### Table 3: Primary indication for surgery, orthopaedic procedures, NHS hospitals, England, Apr 2016 to Mar 2017

<table>
<thead>
<tr>
<th>Surgical Procedure</th>
<th>No. operations</th>
<th>Osteoarthritis No. (%)</th>
<th>Inflammatory joint disease No. (%)</th>
<th>Avascular necrosis No. (%)</th>
<th>Trauma No. (%)</th>
<th>Other No. (%)</th>
<th>Fracture No. (%)</th>
<th>Infection No. (%)</th>
<th>Other No. (%)</th>
<th>Unknown No. (%)</th>
<th>All No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip replacement</td>
<td>41,009</td>
<td>33,526 (81.8)</td>
<td>279 (0.7)</td>
<td>349 (0.9)</td>
<td>2,192 (5.3)</td>
<td>856 (2.1)</td>
<td>410 (1.0)</td>
<td>361 (0.9)</td>
<td>2,730 (6.7)</td>
<td>306 (0.7)</td>
<td>3,807 (9.3)</td>
</tr>
<tr>
<td>Knee replacement</td>
<td>44,188</td>
<td>40,616 (91.9)</td>
<td>369 (0.8)</td>
<td>37 (0.1)</td>
<td>100 (0.2)</td>
<td>639 (1.4)</td>
<td>79 (0.2)</td>
<td>336 (0.8)</td>
<td>1,745 (3.9)</td>
<td>267 (0.6)</td>
<td>2,427 (5.5)</td>
</tr>
</tbody>
</table>
3. Cumulative incidence (%) of SSI

3.1 Incidence (%) of inpatient and readmission SSI by surgical category

Table 4 shows the volume of surgical procedures, the number of SSI cases and the cumulative SSI incidence (%) by surgical category for surgery undertaken between April 2012 and March 2017. Five-year aggregated data were used for robust benchmarking purposes. Over this period, data for a total of 662,743 procedures across 17 surgical categories were submitted by 221 participating NHS hospitals representing 147 NHS trusts. An additional nine NHS treatment centres participated in the surveillance.

The cumulative incidence (%) of SSI varied by surgical category (Table 4) depending on the inherent microbial contamination at the operative site for the type of surgery. The highest incidence (risk) was observed in large bowel surgery at 9.2%. The lowest incidence was in hip and knee prosthesis surgery (0.6% each).

SSIs detected through readmission accounted for a high proportion of inpatient and readmission cases in surgical categories with a relatively short length of hospital stay such as breast surgery (87%), knee prosthesis (74%), abdominal hysterectomy (68%), and hip prosthesis (67%). In categories with longer length of hospital stay (repair of neck of femur, bowel, cardiac non-CABG and limb amputation surgery), readmission SSIs accounted for ≤34% of SSIs detected.

To take into account the variation in the length of patient follow-up during hospital stay, the incidence density was computed, expressed as the number of SSIs per 1,000 days of inpatient follow-up. Using this metric, the variation between surgical categories was less pronounced compared to the inpatient-based cumulative incidence. However, large bowel surgery remains as having the highest SSI incidence density (7.4/1,000) and hip and knee surgery as the lowest (<0.5/1,000) (Table 4).

Tables 5-6 present 5-year benchmarks (to March 2017) for hip and knee prosthesis stratified by primary and revision procedures. This analysis excluded records with three-character OPCS codes (Office of Population Censuses and Surveys classification of interventions and procedures), as it was not possible to distinguish between primary and revision procedures using standard definitions [10]. Records with missing OPCS codes were also excluded. The total excluded was 0.9% of hip (1,721/198,180) and 1.0% of knee procedures (2,171/206,994). In both modules the SSI incidence for revision surgery was higher compared to primary surgery. For knee prosthesis, time to onset of SSI was slightly more delayed for revision compared to primary procedures (21 and 19 days respectively). For hip prosthesis, time to onset of SSI was marginally earlier for revision compared to primary procedures (16 and 18 days respectively).
### Table 4: Cumulative SSI incidence (%) by surgical category, NHS hospitals in England, April 2012 to March 2017

<table>
<thead>
<tr>
<th>Surgical Site Infections</th>
<th>No. operations</th>
<th>No. hospitals</th>
<th>No. Inpatient &amp; readmission</th>
<th>Inpatient &amp; readmission %</th>
<th>95% CIs</th>
<th>Median time to infection (days)*</th>
<th>Incidence density/1,000 inpatient days†</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal hysterectomy</td>
<td>2,921</td>
<td>19</td>
<td>13</td>
<td>41</td>
<td>1.4</td>
<td>1.0 - 1.9</td>
<td>10</td>
<td>1.3</td>
</tr>
<tr>
<td>Bile duct, liver or pancreatic surgery</td>
<td>2,544</td>
<td>7</td>
<td>132</td>
<td>152</td>
<td>6.0</td>
<td>5.1 - 7.0</td>
<td>8</td>
<td>5.7</td>
</tr>
<tr>
<td>Breast</td>
<td>18,096</td>
<td>36</td>
<td>20</td>
<td>155</td>
<td>0.9</td>
<td>0.7 - 1.0</td>
<td>15</td>
<td>0.6</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>1,952</td>
<td>8</td>
<td>32</td>
<td>52</td>
<td>2.7</td>
<td>2.0 - 3.5</td>
<td>6</td>
<td>4.8</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>29,486</td>
<td>21</td>
<td>721</td>
<td>1,126</td>
<td>3.8</td>
<td>3.6 - 4.0</td>
<td>13</td>
<td>2.5</td>
</tr>
<tr>
<td>Cardiac (non-CABG)</td>
<td>14,952</td>
<td>16</td>
<td>128</td>
<td>193</td>
<td>1.3</td>
<td>1.1 - 1.5</td>
<td>14</td>
<td>0.7</td>
</tr>
<tr>
<td>Cranial</td>
<td>8,441</td>
<td>10</td>
<td>56</td>
<td>136</td>
<td>1.6</td>
<td>1.4 - 1.9</td>
<td>19</td>
<td>0.8</td>
</tr>
<tr>
<td>Gastric</td>
<td>1,763</td>
<td>9</td>
<td>35</td>
<td>39</td>
<td>2.2</td>
<td>1.6 - 3.0</td>
<td>8</td>
<td>2.6</td>
</tr>
<tr>
<td>Hip prosthesis</td>
<td>198,180</td>
<td>192</td>
<td>415</td>
<td>1,264</td>
<td>0.6</td>
<td>0.6 - 0.7</td>
<td>17</td>
<td>0.4</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>206,994</td>
<td>181</td>
<td>295</td>
<td>1,155</td>
<td>0.6</td>
<td>0.5 - 0.6</td>
<td>19</td>
<td>0.3</td>
</tr>
<tr>
<td>Large bowel</td>
<td>19,773</td>
<td>53</td>
<td>1,538</td>
<td>1,814</td>
<td>9.2</td>
<td>8.8 - 9.6</td>
<td>8</td>
<td>7.4</td>
</tr>
<tr>
<td>Limb amputation</td>
<td>1,990</td>
<td>14</td>
<td>38</td>
<td>55</td>
<td>2.8</td>
<td>2.1 - 3.6</td>
<td>13</td>
<td>1.6</td>
</tr>
<tr>
<td>Reduction of long bone fracture</td>
<td>12,298</td>
<td>34</td>
<td>69</td>
<td>128</td>
<td>1.0</td>
<td>0.9 - 1.2</td>
<td>17</td>
<td>0.6</td>
</tr>
<tr>
<td>Repair of neck of femur</td>
<td>95,585</td>
<td>114</td>
<td>770</td>
<td>1,073</td>
<td>1.1</td>
<td>1.1 - 1.2</td>
<td>16</td>
<td>0.5</td>
</tr>
<tr>
<td>Small bowel</td>
<td>4,640</td>
<td>21</td>
<td>261</td>
<td>304</td>
<td>6.6</td>
<td>5.9 - 7.3</td>
<td>8</td>
<td>4.8</td>
</tr>
<tr>
<td>Spinal</td>
<td>36,814</td>
<td>25</td>
<td>226</td>
<td>524</td>
<td>1.4</td>
<td>1.3 - 1.5</td>
<td>14</td>
<td>1.0</td>
</tr>
<tr>
<td>Vascular</td>
<td>6,314</td>
<td>16</td>
<td>100</td>
<td>171</td>
<td>2.7</td>
<td>2.3 - 3.1</td>
<td>13</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>662,743</strong></td>
<td><strong>230</strong></td>
<td><strong>4,849</strong></td>
<td><strong>8,382</strong></td>
<td><strong>2.1</strong></td>
<td><strong>1.7 - 2.5</strong></td>
<td><strong>13</strong></td>
<td><strong>2.1</strong></td>
</tr>
</tbody>
</table>

* six records excluded due to missing operation or hospital discharge date or invalid dates given

---

**Surveillance of surgical site infections in NHS hospitals in England, Apr 2016 to Mar 2017**
### Table 5: Cumulative SSI incidence (%) in primary procedures, orthopaedic categories, NHS hospitals in England, April 2012 to March 2017

<table>
<thead>
<tr>
<th>Surgical Site Infections</th>
<th>No. operations</th>
<th>No. hospitals</th>
<th>No. Inpatient</th>
<th>No. inpatient &amp; readmission</th>
<th>Inpatient &amp; readmission %</th>
<th>95% CIs</th>
<th>Median time to infection (days)</th>
<th>Incidence density/1,000 inpatient days</th>
<th>95% CIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip prosthesis</td>
<td>175,454</td>
<td>192</td>
<td>270</td>
<td>975</td>
<td>0.6</td>
<td>0.5 - 0.6</td>
<td>18</td>
<td>0.3</td>
<td>0.3 - 0.3</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>192,659</td>
<td>181</td>
<td>229</td>
<td>972</td>
<td>0.5</td>
<td>0.5 - 0.5</td>
<td>19</td>
<td>0.2</td>
<td>0.2 - 0.3</td>
</tr>
</tbody>
</table>

*Two records excluded due to invalid dates given

### Table 6: Cumulative SSI incidence (%) in revision procedures, orthopaedic categories, NHS hospitals in England, April 2012 to March 2017

<table>
<thead>
<tr>
<th>Surgical Site Infections</th>
<th>No. operations</th>
<th>No. hospitals</th>
<th>No. Inpatient</th>
<th>No. inpatient &amp; readmission</th>
<th>Inpatient &amp; readmission %</th>
<th>95% CIs</th>
<th>Median time to infection (days)</th>
<th>Incidence density/1,000 inpatient days</th>
<th>95% CIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip prosthesis</td>
<td>21,005</td>
<td>178</td>
<td>270</td>
<td>975</td>
<td>1.3</td>
<td>1.1 - 1.4</td>
<td>16</td>
<td>0.7</td>
<td>0.6 - 0.8</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>12,164</td>
<td>174</td>
<td>56</td>
<td>166</td>
<td>1.4</td>
<td>1.2 - 1.6</td>
<td>21</td>
<td>0.6</td>
<td>0.4 - 0.7</td>
</tr>
</tbody>
</table>

**One record excluded due to invalid dates given**
3.2 Risk factors for SSI

Figure 3 shows the cumulative incidence of inpatient/readmission SSIs for selected risk factors by surgical category based on data for Apr 2016 to Mar 2017. The selected risk factors presented are age, ASA score, 'T-time' (duration of operation in minutes dichotomised into two groups – see Section 1.3), and BMI. The BMI analysis was restricted to surgical categories where BMI data completion was ≥50% of submitted records.

Differences in the SSI incidence between the youngest (<45 years) and oldest patients (≥65 years) were observed in some surgical categories. For the majority of surgical categories, the SSI incidence was highest among patients aged ≥65 years compared to other age groups particularly in bile duct/liver/pancreatic surgery, which showed the elderly having the highest risk (7.0%). Some categories exhibited a bimodal pattern of risk with the youngest and oldest having the highest risk, the effects being most pronounced in abdominal hysterectomy and spinal surgery.

Patients with an ASA score of ≥3 typically had an increased SSI incidence. Duration of operation greater than the NHSN 75th percentile for that category also had an increased risk of SSI compared to procedures below this threshold across all surgical categories. Excess risk for longer duration of procedures was most marked in bile duct/liver/pancreatic, cholecystectomy, breast and gastric surgery.

The risk of SSI increased among patients who were obese (BMI ≥30kg/m²) in the majority of surgical categories examined with the exception of bile duct/liver/pancreatic and cranial surgery, where the reverse pattern was observed. For knee prosthesis, the SSI risk was similar in both groups.

Table 7 shows the SSI incidence by primary indication for hip prosthesis, knee prosthesis and repair of neck of femur in Apr 2016 to Mar 2017. For hip prosthesis, the risk of SSI was highest for surgery to treat avascular necrosis (1.7%), a finding that was higher than in previous reports [11;12]. The highest risk in hip prosthesis is typically for surgery where the primary indication is revision. For example, data for Apr 2015 to Mar 2016 showed the SSI risk in hip prosthesis was highest for revision due to a previous infection (3.8%) [12]. In knee prosthesis, the SSI incidence was highest for revision due to fracture (5.1%). The latter result was based on relatively small sample size (n=79). Overall primary procedures carried a lower SSI risk than revision procedures in both surgical categories.
Figure 3: Stratification of the inpatient/readmission SSI incidence, selected risk factors, by surgical category, NHS hospitals, England Apr 2016 to Mar 2017

*coronary artery bypass graft

*BMI analysis is based on surgical categories where the BMI data completion was ≥50%
Table 7: SSI incidence by primary indication for surgery in orthopaedic categories, NHS hospitals, England, Apr 2016 to Mar 2017

<table>
<thead>
<tr>
<th>Primary Indication</th>
<th>Hip prosthesis</th>
<th>Knee prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. operations</td>
<td>No. SSI</td>
</tr>
<tr>
<td>Primary procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>33,526</td>
<td>166</td>
</tr>
<tr>
<td>Inflammatory joint disease</td>
<td>279</td>
<td>1</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>349</td>
<td>6</td>
</tr>
<tr>
<td>Fracture</td>
<td>2,192</td>
<td>18</td>
</tr>
<tr>
<td>Other</td>
<td>856</td>
<td>7</td>
</tr>
<tr>
<td>All primary procedures</td>
<td>37,202</td>
<td>198</td>
</tr>
<tr>
<td>Revision procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>361</td>
<td>2</td>
</tr>
<tr>
<td>Fracture</td>
<td>410</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>2,730</td>
<td>27</td>
</tr>
<tr>
<td>Unknown</td>
<td>306</td>
<td>3</td>
</tr>
<tr>
<td>All revision procedures</td>
<td>3,807</td>
<td>38</td>
</tr>
</tbody>
</table>
4. Trends in the incidence of SSI

4.1 Orthopaedic categories

Figure 4 shows trends in the crude cumulative incidence of SSI in the mandatory orthopaedic categories between Apr 2004 to Mar 2005 and Apr 2016 to Mar 2017. Three types of trends are shown: inpatient-detected, readmission-detected and combined inpatient and readmission SSIs.

The crude inpatient/readmission SSI incidence in hip prosthesis exhibited small variation initially from Apr 2008 to Mar 2009 to Apr 2012 to Mar 2013 stabilising to 0.6% in the last three successive years ending Apr 2016 to Mar 2017. In knee prosthesis, small incremental increases occurred initially from Apr 2008 to Mar 2009 to Apr 2011 to Mar 2012 but this was followed by marginal decreases, stabilising to 0.5% in the last three successive years to Apr 2016 to Mar 2017.

Reduction of long bone fracture exhibited a curvilinear trend with successive reductions from 1.4% in Apr 2014 to Mar 2015 to 0.7% in Apr 2016 to Mar 2017. Repair of neck of femur exhibited ongoing decreases in the crude incidence from 1.7% in Apr 2008 to Mar 2009 to 1.0% in Apr 2016 to Mar 2017.

Figure 4: Trends in the annual cumulative incidence of SSI (%) in orthopaedic surveillance categories, with lower and upper 95% CIs, NHS hospitals in England
4.2 Non-orthopaedic categories

Figures 5-7 show the trends in the crude inpatient, readmission and the combined inpatient and readmission SSI incidence for the voluntary non-orthopaedic categories. Surgical categories introduced after July 2008 are presented last. For most of the 13 voluntary surgical categories, the trends in the crude SSI incidence were mostly curvilinear e.g. breast, cranial and large bowel surgery.

Among the gastro-intestinal categories (Figure 5), large bowel surgery showed a general decline in SSI incidence after Apr 2011 to Mar 2012 reducing from 11.1% in that year to 7.8% in Apr 2016 to Mar 2017, with successive reduction in the last 2 years. The incidence also reduced in the last 2 years for small bowel surgery (7.6% in Apr 2015 to Mar 2016 and 5.0% in Apr 2016 to Mar 2017).

CABG showed a generally downward trend after the peak in Apr 2009 to Mar 2010 (5.7%) reducing to 3.8% in Apr 2016 to Mar 2017 despite small inter-year variation in the last 3 years (Figure 6). Cardiac non-CABG showed a generally upward trend from 1.0% in Apr 2010 to Mar 2011 to 1.7% in Apr 2016 to Mar 2017. Limb amputation exhibited a reduction in the SSI incidence only in recent years from 4.1% in Apr 2014 Mar 2015 to 2.0% in Apr 2016 to Mar 2017 despite small variation the last 2 years. No trend was evident for vascular surgery.

Figure 5: Trends in the annual cumulative incidence of SSI (%) in gastro-intestinal surveillance categories with lower and upper 95% CIs, NHS hospitals in England
For the remaining surgical categories (Figure 7), abdominal hysterectomy did not show clear trends until the last 2 years where successive increases occurred (1.4% in Apr 2015 to 2016 and 2.4% in Apr 2016 to Mar 2017). Cranial surgery exhibited a generally upward trend (from 0.9% in Apr 2010 to Mar 2011 to 2.0% in Apr 2016 to Mar 2017), with successive increases in the last 2 years. Spinal surgery exhibited a generally upward trend after Apr 2009 to Mar 2010, increasing from 0.9% in that year to 1.4% in Apr 2016 to Mar 2017. No trend was evident for breast surgery.

**Figure 6: Trends in the annual cumulative incidence of SSI (%) in cardiac and vascular surveillance categories with lower and upper 95% CIs, NHS hospitals in England**
4.3 Modelled trends

To evaluate changes in SSI, a logistic regression model was fitted to binomial data from Apr 2009 to Mar 2010 to Apr 2016 to Mar 2017. The year Apr 2009 to Mar 2010 was used as baseline as this comprised a full financial year with full readmission surveillance data. A univariable model (without risk adjustment) was used to compare the odds of inpatient and readmission SSI in Apr 2016 to Mar 2017 to the odds in the baseline year Apr 2009 to Mar 2010 (giving the Odds Ratio). A multivariable model was also used which adjusted for length of hospital stay (from admission to discharge date in days), as a continuous variable. Length of stay was formed into a categorical variable (<5, 5-14, 15-30 and >30 days) for cholecystectomy to handle sparse data. For hip prosthesis, knee prosthesis and repair of neck of femur, primary indication for surgery (e.g. osteoarthritis, revision) was also included in the multivariable model. Table 8 summarises the results for all 17 modules.

The analysis comparing the odds of SSI in Apr 2016 to Mar 2017 to the odds in the baseline Apr 2009 to Mar 2010 using the Odds Ratio (Table 8), showed that of 4 orthopaedic categories, only repair of neck of femur and reduction of long bone fracture had significant reductions in SSI even after risk adjustment i.e. length of hospital stay and primary indication (adjusted OR: 0.60; 95% CI: 0.49 – 0.73 and adjusted OR:0.47:
95% CI: 0.26 – 0.83 respectively). The corresponding crude trends showed a reduction from 1.6% to 1.0% for repair of neck of femur and from 1.5% to 0.7% for reduction of long bone fracture.

The modelled data for the non-mandatory categories revealed 4 surgical categories with important changes.

CABG showed a significant reduction in SSI even after risk adjustment i.e. length of stay (adjusted OR: 0.58; 95% CI: 0.48 – 0.70). The crude SSI incidence in this category reduced from 5.7% in Apr 2009 to Mar 2010 to 3.8% in Apr 2016 to Mar 2017.

In spinal surgery, the increase from 0.9% in 2009/10 to 1.4% in Apr 2016 to Mar 2017 was significant in the modelled data. The corresponding adjusted OR was 1.57 (95% CI: 1.05 – 2.35). A significant increase also occurred for cholecystectomy from 0.9% in 2010/11 (baseline) to 3.0% in Apr 2016 to Mar 2017. The corresponding adjusted OR was 8.52 (95% CI: 1.69 – 42.95. However, the underlying volume for cholecystectomy was small (n=2,503) in addition to sparse data for longer length of hospital stay (despite using a categorical variable with four strata) – yielding a wide confidence interval range for the true population increase. The increase in SSI for cholecystectomy may reflect an increasing pool of patients included in the surveillance with complex conditions requiring open surgery.

In cardiac non-CABG surgery the increase from 1.0% in Apr 2010 to Mar 2011 (baseline) to 1.7% in Apr 2016 to Mar 2017 was significant although the corresponding adjusted OR was 1.61 (95% CI: 0.92 – 2.81) was of borderline significance (p=0.098). Although the result for cardiac non-CABG surgery is inconclusive the increase in SSI in this category may be clinically important and merits further study.
Table 8: Inpatient/readmission SSI in Apr 2016 to Mar 2017 compared to the baseline year Apr 2009 to Mar 2010 using Odds Ratio, by surgical category, NHS hospitals, England

<table>
<thead>
<tr>
<th>Surgical category</th>
<th>No. of operations</th>
<th>Odds Ratio 95% CI</th>
<th>P</th>
<th>Odds Ratio 95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal hysterectomy</td>
<td>6,091</td>
<td>1.26</td>
<td>0.61 - 2.62</td>
<td>0.537</td>
<td>1.35</td>
</tr>
<tr>
<td>Bile duct, liver or pancreatic surgery</td>
<td>3,917</td>
<td>0.62</td>
<td>0.37 - 1.03</td>
<td>0.066</td>
<td>1.13</td>
</tr>
<tr>
<td>Breast*</td>
<td>21,210</td>
<td>0.79</td>
<td>0.44 - 1.41</td>
<td>0.428</td>
<td>0.72</td>
</tr>
<tr>
<td>Cardiac (non-CABG)*</td>
<td>19,093</td>
<td>1.65</td>
<td>0.95 - 2.88</td>
<td>0.075</td>
<td>1.61</td>
</tr>
<tr>
<td>Cholecystectomy†</td>
<td>2,503</td>
<td>3.42</td>
<td>0.74 - 15.76</td>
<td>0.115</td>
<td>8.52</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>47,411</td>
<td>0.69</td>
<td>0.58 - 0.82</td>
<td>&lt;0.001</td>
<td>0.58</td>
</tr>
<tr>
<td>Cranial*</td>
<td>9,612</td>
<td>2.21</td>
<td>0.86 - 5.64</td>
<td>0.098</td>
<td>2.12</td>
</tr>
<tr>
<td>Gastric</td>
<td>2,627</td>
<td>1.23</td>
<td>0.41 - 3.71</td>
<td>0.711</td>
<td>1.49</td>
</tr>
<tr>
<td>Hip prosthesis†</td>
<td>292,508</td>
<td>0.93</td>
<td>0.76 - 1.13</td>
<td>0.437</td>
<td>0.98</td>
</tr>
<tr>
<td>Knee prosthesis†</td>
<td>308,758</td>
<td>0.95</td>
<td>0.78 - 1.16</td>
<td>0.605</td>
<td>1.04</td>
</tr>
<tr>
<td>Large bowel</td>
<td>30,473</td>
<td>0.86</td>
<td>0.73 - 1.02</td>
<td>0.086</td>
<td>0.92</td>
</tr>
<tr>
<td>Limb amputation</td>
<td>3,357</td>
<td>0.54</td>
<td>0.22 - 1.30</td>
<td>0.168</td>
<td>0.60</td>
</tr>
<tr>
<td>Reduction of long bone fracture</td>
<td>21,602</td>
<td>0.49</td>
<td>0.27 - 0.86</td>
<td>0.013</td>
<td>0.47</td>
</tr>
<tr>
<td>Repair of neck of femur†</td>
<td>141,173</td>
<td>0.61</td>
<td>0.50 - 0.74</td>
<td>&lt;0.001</td>
<td>0.60</td>
</tr>
<tr>
<td>Small bowel</td>
<td>6,905</td>
<td>0.89</td>
<td>0.59 - 1.36</td>
<td>0.604</td>
<td>0.89</td>
</tr>
<tr>
<td>Spinal</td>
<td>52,650</td>
<td>1.66</td>
<td>1.12 - 2.47</td>
<td>0.012</td>
<td>1.57</td>
</tr>
<tr>
<td>Vascular</td>
<td>10,534</td>
<td>0.85</td>
<td>0.54 - 1.35</td>
<td>0.488</td>
<td>1.17</td>
</tr>
</tbody>
</table>

* baseline year is 2010/11; †length of stay was grouped into four strata in this surgical category (<5, 5-14, 15-30 and >30 days); ‡adjusted for length of hospital stay from admission to discharge date (days) in all categories along with primary indication for surgery for hip and knee prosthesis and repair of neck of femur.
5. Characteristics of surgical site infections

5.1 Type of SSI

Figures 8 and 9 show the distribution of SSI type for inpatient cases in Apr 2016 to Mar 2017 compared to inpatient and re-admission cases combined by surgical category.

Information on SSI type was available for all 1,635 SSIs detected through inpatient or readmission surveillance in Apr 2016 to Mar 2017 (all surgical categories). SSI type data from eight surgical categories with ≥45 inpatient and readmission SSIs were analysed (n=1,445).

In Apr 2016 to Mar 2017, the proportion of inpatient-detected SSIs that were superficial incisional infections varied by surgical category, ranging from 37.5% in spinal surgery to 69.8% in small bowel surgery. The observed proportions are likely to be affected by differences in the length of post-operative hospital stay between surgical categories.

As readmission-detected SSIs will involve more serious wound complications, inclusion of these cases tended to increase the proportion of deep SSIs particularly in surgical categories where the median length of hospital stay was relatively short. For example, in hip and knee prosthesis surgery, the proportion of inpatient and readmission-detected infections that were deep increased to 44% and 47%, respectively, compared with the proportions based on inpatient-detected cases alone (35.6% and 22.7%, respectively). A similar pattern was observed for the organ-space SSIs although inclusion of readmission cases did not alter this proportion for repair of neck of femur, bowel and spinal surgery (being comparable to proportions based on inpatient-detected cases).

In most other voluntary categories included in this analysis, the median length of hospital stay was longer than that for hip or knee prosthesis. However, typically, the proportion of inpatient and readmission SSIs that were deep or organ-space was broadly similar to the corresponding proportion for inpatient-detected SSIs.
Surveillance of surgical site infections in NHS hospitals in England, Apr 2016 to Mar 2017

Figure 8: Distribution of SSI type in inpatient cases compared to combined inpatient and readmission cases, orthopaedic surgery, NHS hospitals in England, Apr 2016 to Mar 2017

- Inpatient (n=59)
  - Superficial: 45.8%
  - Deep: 35.6%
  - Organ-space: 18.6%

- Inpatient (n=241)
  - Superficial: 30.7%
  - Deep: 44.0%
  - Organ-space: 25.3%

- Inpatient (n=44)
  - Superficial: 63.6%
  - Deep: 22.7%
  - Organ-space: 13.6%

- Inpatient (n=232)
  - Superficial: 34.5%
  - Deep: 47.0%
  - Organ-space: 18.5%

- Inpatient (n=123)
  - Superficial: 39.8%
  - Deep: 39.8%
  - Organ-space: 20.3%

- Inpatient (n=192)
  - Superficial: 30.7%
  - Deep: 50.0%
  - Organ-space: 19.3%

% of total SSI type

- Superficial
- Deep
- Organ-space

Figure 9: Distribution of SSI type in inpatient cases compared to combined cases, non-orthopaedic surgery, NHS hospitals in England, Apr 2016 to Mar 2017

- Inpatient (n=128)
  - Cardiac (non-CABG*): 63.3%
  - CABG*: 35.2%

- Inpatient (n=237)
  - Cardiac (non-CABG*): 54.9%
  - CABG*: 38.8%

- Inpatient (n=42)
  - Cardiac (non-CABG*): 52.4%
  - CABG*: 28.6%

- Inpatient (n=62)
  - Cardiac (non-CABG*): 45.2%
  - CABG*: 38.7%

- Inpatient (n=281)
  - Cardiac (non-CABG*): 58.0%
  - CABG*: 17.4%

- Inpatient (n=330)
  - Cardiac (non-CABG*): 55.8%
  - CABG*: 19.7%

- Inpatient (n=43)
  - Small bowel: 69.8%
  - Spinal: 16.3%

- Inpatient (n=55)
  - Small bowel: 69.1%
  - Spinal: 16.4%

- Inpatient (n=32)
  - Small bowel: 37.5%
  - Spinal: 50.0%

- Inpatient (n=96)
  - Small bowel: 29.2%
  - Spinal: 60.4%

% of total SSI type

- Cardiac (non-CABG*)
- CABG*
- Large bowel
- Small bowel
- Spinal

*coronary artery bypass graft
5.2 Causative micro-organisms

Figure 10 shows trends in organisms reported as causing inpatient SSIs from Apr 2006 to Mar 2007 to Apr 2016 to Mar 2017 based on data from all surgical categories except breast, cardiac (non-CABG), cranial and spinal surgery as these modules were introduced more recently (after July 2008). Inpatient SSIs were analysed to remove the effect of readmission surveillance introduced in July 2008. Overall, of 10,874 inpatient SSIs detected over this 11-year period, 65% (n=7,082) had data on microbial aetiology reported as causing SSI.

Trends in microbial aetiology based on inpatient and readmission cases from July 2008 to Apr 2016 to Mar 2017 were also assessed in order to compare with inpatient-detected trends for recent years (Figure 11). Prior to July 2008 readmission surveillance was voluntary. To permit comparisons, the same surgical categories were excluded as in the inpatient analysis. Overall, of 14,235 inpatient /readmission SSIs detected over this 9 year period, 67% (n=9,544) had data on microbial aetiology reported as causing SSI.


Methicillin-susceptible *S. aureus* (MSSA) did not exhibit a discernible trend until small decreases emerged over the last 4 successive years: Apr 2013 to Mar 2014 (12%), Apr 2014 to Mar 2015 (11%) and 9% in Apr 2015 to Mar 2016 and Apr 2016 to Mar 2017. *Enterobacteriaceae* accounted for 29% of cases in Apr 2016 to Mar 2017, the highest to date since their increases emerged in Apr 2008 to Mar 2009.

Figure 11 shows trends in aetiology when readmission cases are included. The trends in *S. aureus*, MRSA and *Enterobacteriaceae* are not as marked compared to the corresponding inpatient-based trends. The inclusion of readmission cases attenuates the effects and suggests that hospital-onset cases are mainly driving the trends.

Table 9 shows the distribution of organisms reported to cause inpatient and readmission SSIs for all SSI types by surgical category based on aggregate 3-year data from April 2014 to March 2017. Categories with organism data on ≥200 SSI cases were analysed for statistical precision. Spinal surgery had the highest proportion of SSI cases with microbiology data at 86% (282/329) followed by hip and repair of neck of femur at 80% and 81% respectively. Large bowel surgery had the lowest proportion of SSI cases with microbiology data at 55% (559/1,080). Polymicrobial SSIs (cases with more than one
organism reported as causing SSI) were most frequent in large bowel surgery at 40% (238/559) of cases and lowest in knee prosthesis surgery at 23% (112/487).

Among monomicrobial SSIs (one organism reported as causing SSI), MRSA aetiology was highest in repair of neck of femur, accounting for 9% (30/329) of cases. This may reflect the emergency nature of hip fracture admissions, which may prevent pre-admission screening and eradication of MRSA. The lowest MRSA proportion was in spinal surgery at 3% (6/202).

*S. aureus* aetiology was highest in knee prosthesis accounting for 43% (163/375) of monomicrobial SSIs closely followed by repair of neck of femur at 41% (136/329). Repair of neck of femur showed a decrease in the burden of SSI due to *S. aureus* from 44% (3-year data to Apr 2015 to Mar 2016) to 41% (3-year data to Apr 2016 to Mar 2017).

SSIs caused by Enterobacteriaceae were highest in large bowel at 53% (192/361) followed by CABG surgery at 29% (74/256) (3-year data to Apr 2016 to Mar 2017). Only CABG and hip prosthesis surgery showed increases (to 22% and 29% respectively) compared to the corresponding proportions for 3-year data to Apr 2015 to Mar 2016 (19% and 26% respectively).

Organisms reported as ‘coliforms’ accounted for 22% (112/501) of all monomicrobial Enterobacteriaceae SSIs for the studied categories between Apr 2014 and Mar 2017. Hence an analysis by species could not be undertaken.

The proportion of SSIs caused by coagulase-negative staphyloccoci (CoNS), which tend to be associated with implants, was highest in spinal surgery (28% of monomicrobial SSIs; 56/202), followed by CABG surgery (26%). This exceeded the proportion in spinal surgery in previous years [11;12] and may reflect increased use of implants in spinal surgery.

Mycobacteria were not reported as causing SSIs in any of the 17 surgical categories under survey in this period (April 2014 to March 2017).

Among polymicrobial infections, Gram-positive and Gram-negative combinations were the most frequent type in repair of neck of femur, CABG and large bowel surgery (range: 45% - 50%).

Table 10 shows the distribution of organisms causing deep/organ-space SSIs detected during inpatient stay or on readmission for the same selected categories and time period (April 2014 to March 2017). The distribution of monomicrobial organisms was broadly similar to that for all SSI types with two exceptions. In repair of neck of femur surgery, the proportion of deep/organ-space SSIs reported to be caused by CoNS was
elevated at 21% (47/229) compared to 16% based on all SSI types. In large bowel surgery, the proportion due to Enterobacteriaceae was elevated at 59% (68/115) compared to 53% for all SSI types. In the polymicrobial subset, the distribution of organisms was broadly similar to the corresponding data for all SSI types except that the proportion of purely Gram-positive combinations was elevated in spinal (65%) and knee prosthesis surgery (51%) compared to corresponding proportions based on all SSI types (56% and 41% respectively). The burden of certain organisms identified in this subset of serious infections warrants closer vigilance.

Figure 12 shows the distribution of organisms (counts) by SSI anatomical site collected only for organ-space SSIs. Data for selected surgical categories are presented. This analysis was expanded to 5 years from April 2012 to March 2017 to maximise statistical precision for this very small subset of infections. Reporting of SSI site was 100% in hip prosthesis, CABG, and spinal surgery and 99.6% in knee prosthesis. For all organ-space infections with anatomical site data, organism data were available for 90%, 87%, 91% and 89% of infections in these categories, respectively. The final samples available for analysis for these categories were n=286, n=71, n=42 and n=216, respectively, although small in some.

Joint bursa was the most frequent focus for organ-space SSI in hip and knee prosthesis, (n=270 and n=213, respectively). Among joint bursa SSIs of monomicrobial aetiology, staphylococci followed by Enterobacteriaceae were the most common causes although for hip prosthesis, Enterobacteriaceae were more frequent compared to those in knee prosthesis (n=35 and n=19 respectively). Osteomyelitis was an infrequent organ-space SSI in these orthopaedic categories but predominantly caused by staphylococci (S. aureus and CoNs combined). In CABG surgery, mediastinitis was the most frequent organ-space SSI overall (n=44). Among monomicrobial mediastinum SSIs, staphylococci were the predominant causes followed by Enterobacteriaceae. Of endocarditis SSIs with monomicrobial aetiology, the predominant causes were staphylococci, particularly CoNS. Overall, spinal abscess (without meningitis) was the most frequent organ-space SSI (n=21) in spinal surgery. Among spinal abscess SSIs of monomicrobial aetiology, staphylococci (n=7) followed by Enterobacteriaceae (n=5) were the predominant causes.
Figure 10: Trends in micro-organisms reported as causing inpatient SSIs, all surgical categories*, NHS hospitals, England

Figure 11: Trends in micro-organisms reported as causing inpatient/readmission SSIs, all surgical categories*, NHS hospitals, England

*excludes breast, cardiac (non-CABG), cranial and spinal surgery; †coagulase-negative staphylococci; ‡readmission surveillance prior to July 2008 was voluntary; §2008/9 based on data from July 2008
Surveillance of surgical site infections in NHS hospitals in England, 2016 to 2017

Table 9: Distribution of micro-organisms reported as causing SSI (inpatient/readmission), all SSI types, by surgical category, NHS hospitals, England, April 2014 to March 2017

<table>
<thead>
<tr>
<th>Reported causative organism</th>
<th>Hip Prosthesis</th>
<th>Knee Prosthesis</th>
<th>Repair of neck of femur</th>
<th>CABG</th>
<th>Large bowel</th>
<th>Spinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methicillin-sensitive <em>S. aureus</em></td>
<td>112 (28.4%)</td>
<td>144 (38.4%)</td>
<td>106 (32.2%)</td>
<td>50 (19.5%)</td>
<td>16 (4.4%)</td>
<td>75 (37.1%)</td>
</tr>
<tr>
<td>Methicillin-resistant <em>S. aureus</em></td>
<td>17 (4.3%)</td>
<td>19 (5.1%)</td>
<td>30 (9.1%)</td>
<td>13 (5.1%)</td>
<td>7 (1.9%)</td>
<td>6 (3.0%)</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>99 (25.1%)</td>
<td>88 (23.5%)</td>
<td>54 (16.4%)</td>
<td>67 (26.2%)</td>
<td>7 (1.9%)</td>
<td>56 (27.7%)</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>85 (21.5%)</td>
<td>37 (9.9%)</td>
<td>76 (23.1%)</td>
<td>74 (28.9%)</td>
<td>192 (53.2%)</td>
<td>37 (18.3%)</td>
</tr>
<tr>
<td><em>Pseudomonas</em> spp.</td>
<td>17 (4.3%)</td>
<td>13 (3.5%)</td>
<td>18 (5.5%)</td>
<td>28 (10.9%)</td>
<td>37 (10.2%)</td>
<td>8 (4.0%)</td>
</tr>
<tr>
<td><em>Streptococcus</em> spp.</td>
<td>24 (6.1%)</td>
<td>31 (8.3%)</td>
<td>12 (3.6%)</td>
<td>4 (1.6%)</td>
<td>13 (3.6%)</td>
<td>4 (2.0%)</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp.</td>
<td>21 (5.3%)</td>
<td>16 (4.3%)</td>
<td>21 (6.4%)</td>
<td>4 (1.6%)</td>
<td>23 (6.4%)</td>
<td>4 (2.0%)</td>
</tr>
<tr>
<td>Other bacteria</td>
<td>19 (4.8%)</td>
<td>26 (6.9%)</td>
<td>9 (2.7%)</td>
<td>15 (5.9%)</td>
<td>50 (13.9%)</td>
<td>11 (5.4%)</td>
</tr>
<tr>
<td>Fungi including <em>Candida</em> spp.</td>
<td>1 (0.3%)</td>
<td>1 (0.3%)</td>
<td>3 (0.9%)</td>
<td>1 (0.4%)</td>
<td>16 (4.4%)</td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td><strong>Total monomicrobial</strong></td>
<td>395 (100%)</td>
<td>375 (100%)</td>
<td>329 (100%)</td>
<td>256 (100%)</td>
<td>361 (100%)</td>
<td>202 (100%)</td>
</tr>
<tr>
<td>Gram-positive combinations only</td>
<td>83 (48.3%)</td>
<td>46 (41.1%)</td>
<td>43 (27.6%)</td>
<td>38 (24.7%)</td>
<td>8 (3.4%)</td>
<td>45 (56.3%)</td>
</tr>
<tr>
<td>Gram-negative combinations only</td>
<td>19 (11.0%)</td>
<td>15 (13.4%)</td>
<td>25 (16.0%)</td>
<td>33 (21.4%)</td>
<td>52 (21.8%)</td>
<td>10 (12.5%)</td>
</tr>
<tr>
<td>Gram-positive and Gram-negative combinations</td>
<td>63 (36.6%)</td>
<td>42 (37.5%)</td>
<td>70 (44.9%)</td>
<td>70 (45.5%)</td>
<td>119 (50.0%)</td>
<td>24 (30.0%)</td>
</tr>
<tr>
<td>Other combinations*</td>
<td>7 (4.1%)</td>
<td>9 (8.0%)</td>
<td>18 (11.5%)</td>
<td>13 (8.4%)</td>
<td>59 (24.8%)</td>
<td>1 (1.3%)</td>
</tr>
<tr>
<td><strong>Total polymicrobial</strong></td>
<td>172 (100%)</td>
<td>112 (100%)</td>
<td>156 (100%)</td>
<td>154 (100%)</td>
<td>238 (100%)</td>
<td>80 (100%)</td>
</tr>
<tr>
<td>Cases with organism data (% of total cases)</td>
<td>567 (80.2%)</td>
<td>487 (70.8%)</td>
<td>485 (81.4%)</td>
<td>410 (74.1%)</td>
<td>599 (55.5%)</td>
<td>282 (85.7%)</td>
</tr>
<tr>
<td>Cases without organism data (% of total cases)</td>
<td>140 (19.8%)</td>
<td>201 (29.2%)</td>
<td>111 (18.6%)</td>
<td>143 (25.9%)</td>
<td>481 (44.5%)</td>
<td>47 (14.3%)</td>
</tr>
<tr>
<td><strong>Total SSI cases</strong></td>
<td>707 (100%)</td>
<td>688 (100%)</td>
<td>596 (100%)</td>
<td>553 (100%)</td>
<td>1,080 (100%)</td>
<td>329 (100%)</td>
</tr>
</tbody>
</table>

*a combination that includes 'anaerobic bacilli' 'anaerobic cocci', 'other bacteria' or fungi
Table 10: Distribution of micro-organisms reported as causing deep/organ-space SSI (inpatient/readmission), by surgical category, NHS hospitals, England, April 2014 to March 2017

<table>
<thead>
<tr>
<th>Reported causative organism</th>
<th>Hip Prosthesis</th>
<th>Knee Prosthesis</th>
<th>Repair of neck of femur</th>
<th>CABG</th>
<th>Large bowel</th>
<th>Spinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methicillin-sensitive S. aureus</td>
<td>89 29.3%</td>
<td>118 39.1%</td>
<td>67 29.3%</td>
<td>24  21.2%</td>
<td>3  2.6%</td>
<td>53 36.3%</td>
</tr>
<tr>
<td>Methicillin-resistant S. aureus</td>
<td>14  4.6%</td>
<td>12  4.0%</td>
<td>15  6.6%</td>
<td>6  5.3%</td>
<td>2  1.7%</td>
<td>6  4.1%</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>77 25.3%</td>
<td>70 23.2%</td>
<td>47 20.5%</td>
<td>27  23.9%</td>
<td>4  3.5%</td>
<td>38 26.0%</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>68 22.4%</td>
<td>30  9.9%</td>
<td>54 23.6%</td>
<td>35  31.0%</td>
<td>68 59.1%</td>
<td>29 19.9%</td>
</tr>
<tr>
<td>Pseudomonas spp.</td>
<td>6  2.0%</td>
<td>10  3.3%</td>
<td>12  5.2%</td>
<td>10  8.8%</td>
<td>4  3.5%</td>
<td>5  3.4%</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>21  6.9%</td>
<td>26  8.6%</td>
<td>8  3.5%</td>
<td>2  1.8%</td>
<td>4  3.5%</td>
<td>3  2.1%</td>
</tr>
<tr>
<td>Enterococcus spp.</td>
<td>15  4.9%</td>
<td>12  4.0%</td>
<td>17  7.4%</td>
<td>2  1.8%</td>
<td>7  6.1%</td>
<td>4  2.7%</td>
</tr>
<tr>
<td>Other bacteria</td>
<td>13  4.3%</td>
<td>23  7.6%</td>
<td>23  7.4%</td>
<td>2  1.8%</td>
<td>19 16.5%</td>
<td>7  4.8%</td>
</tr>
<tr>
<td>Fungi including Candida spp.</td>
<td>1  0.3%</td>
<td>1  0.3%</td>
<td>1  0.3%</td>
<td>0  0.0%</td>
<td>4  3.5%</td>
<td>1  0.7%</td>
</tr>
<tr>
<td><strong>Total monomicrobial</strong></td>
<td><strong>304 100%</strong></td>
<td><strong>302 100%</strong></td>
<td><strong>229 100%</strong></td>
<td><strong>113 100%</strong></td>
<td><strong>115 100%</strong></td>
<td><strong>146 100%</strong></td>
</tr>
<tr>
<td>Gram-positive combinations only</td>
<td>69 49.6%</td>
<td>42 50.6%</td>
<td>37 31.4%</td>
<td>23 22.3%</td>
<td>2 1.8%</td>
<td>35 64.8%</td>
</tr>
<tr>
<td>Gram-negative combinations only</td>
<td>14 10.1%</td>
<td>10 12.0%</td>
<td>17 14.4%</td>
<td>25 24.3%</td>
<td>25 22.7%</td>
<td>7 13.0%</td>
</tr>
<tr>
<td>Gram-positive and Gram-negative combinations</td>
<td>51 36.7%</td>
<td>28 33.7%</td>
<td>54 45.8%</td>
<td>42 40.8%</td>
<td>53 48.2%</td>
<td>11 20.4%</td>
</tr>
<tr>
<td>Other combinations*</td>
<td>5  3.6%</td>
<td>3  3.6%</td>
<td>10  8.5%</td>
<td>13 12.6%</td>
<td>30 27.3%</td>
<td>1  1.9%</td>
</tr>
<tr>
<td><strong>Total polymicrobial</strong></td>
<td><strong>139 100%</strong></td>
<td><strong>83 100%</strong></td>
<td><strong>118 100%</strong></td>
<td><strong>103 100%</strong></td>
<td><strong>110 100%</strong></td>
<td><strong>54 100%</strong></td>
</tr>
<tr>
<td>Cases with organism data (% of total cases)</td>
<td>443 87.9%</td>
<td>385 88.7%</td>
<td>347 88.7%</td>
<td>216 85.0%</td>
<td>225 48.0%</td>
<td>200 90.1%</td>
</tr>
<tr>
<td>Cases without organism data (% of total cases)</td>
<td>61 12.1%</td>
<td>49 11.3%</td>
<td>44 11.3%</td>
<td>38 15.0%</td>
<td>244 52.0%</td>
<td>22 9.9%</td>
</tr>
<tr>
<td><strong>Total SSI cases</strong></td>
<td><strong>504 100%</strong></td>
<td><strong>434 100%</strong></td>
<td><strong>391 100%</strong></td>
<td><strong>254 100%</strong></td>
<td><strong>469 100%</strong></td>
<td><strong>222 100%</strong></td>
</tr>
</tbody>
</table>

*a combination that includes 'anaerobic bacilli', 'anaerobic cocci', 'other bacteria' or fungi
Surveillance of surgical site infections in NHS hospitals in England, 2016 to 2017

Figure 12: Distribution of organisms by site of organ-space SSIs (inpatient/readmission), NHS hospitals, England, April 2012 to March 2017

- **Hip prosthesis**
  - Bone (osteomyelitis)
  - Joint/bursa
  - Monomicrobial

- **Knee prosthesis**
  - Bone (osteomyelitis)
  - Joint/bursa
  - Monomicrobial

- **Spinal surgery**
  - Bone (osteomyelitis)
  - Joint/bursa
  - Monomicrobial

- **Coronary artery bypass graft**
  - Bone (osteomyelitis)
  - Endocardium
  - Mediastinum
  - Pericarditis/Mycarditis
  - Monomicrobial

- **Organs**
  - Coronary artery bypass graft
  - Arterial/venous

- **Organ combinations**
  - Gram+ive combinations
  - Gram-ive combinations
  - Gram+ive and Gram-ive
  - Other combinations

- **Organ space SSIs (inpatient/readmission)**
  - MSSA
  - MRSA
  - CoNS
  - Enterobacteriaceae
  - Pseudomonas spp.
  - Streptococcus spp.
  - Enterococcus spp.
  - Other bacteria
  - Fungi including Candida spp.
  - Gram+ive combinations
  - Gram-ive combinations
  - Gram+ive and Gram-ive
  - Other combinations

- **Organizations**
  - Joint/bursa
  - Spinal abscess (without meningitis)
  - Vertebral disc space
  - Polymicrobial
  - Monomicrobial
Figure 13 shows the distribution of organisms in primary total hip prosthesis infections (inpatient and readmission) by fixation type. The analysis was based on infections of monomicrobial aetiology. The data were expanded to 5 years from April 2012 to March 2017 to maximise statistical precision given that this is a small subset of infections. Procedures under the ‘Other’ group (OPCS codes W39, W54 and W58) were excluded as these do not distinguish between fixation types. The analysis showed that of three fixation groups, the uncemented group had the highest proportion of infections due to *S. aureus* at 44% (77/176) compared to 35% (91/263) for the cemented group and 31% (22/70) for the hybrid group. The cemented group had the highest proportion due to Enterobacteriaceae (21%) compared to the other two fixation groups.

**Figure 13: Distribution of SSI organisms (inpatient/readmission) in primary total hip prosthesis by fixation group, NHS hospitals, England, April 2012 to March 2017**
6. Variation in SSI incidence between NHS hospitals

6.1 Box and whisker plots

Figure 14 is a box and whisker plot showing the distribution of individual hospital SSI incidence (%) against five percentiles (10th, 25th, 50th, 75th and 90th) by surgical category. Each percentile represents a value below which a proportion of the total observations lie. The box plots show inter-hospital variation within each surgical category. SSI estimates that lie at extreme ends (above the 90th percentile or below the 10th percentile) may indicate a problem (either excess infections or failure to detect SSIs, respectively) which required further investigation.

Figure 14: Distribution of the cumulative SSI incidence (%) at hospital level* by surgical category, NHS hospitals in England, April 2012 to March 2017

* hospitals with <95 operations in hip, knee or abdominal hysterectomy surgery are excluded; in the remaining categories, hospitals with <45 operations are excluded. For categories with <10 hospital participants, only the distribution without a box plot is presented
6.2 Funnel plots

In Apr 2016 to Mar 2017, data on 101,134 orthopaedic procedures and 674 inpatient/readmission SSIs were submitted by 187 NHS hospitals representing 137 NHS trusts. An additional eight independent sector NHS treatment centres contributed data on 7,268 orthopaedic procedures and seven SSIs. Three NHS trusts performing orthopaedic surgery did not contribute orthopaedic data in Apr 2016 to Mar 2017.

Figure 15 shows funnel plots displaying variation in the trust SSI incidence in Apr 2016 to Mar 2017 by orthopaedic category. The cumulative incidence of SSI per 100 operations is plotted against the number of procedures for each participating NHS site. The upper and lower 95% control limits (dashed black lines) define the ‘limits’ of expected variation. Trusts lying outside these limits are considered to be outliers.

Outlier status should be used as a trigger for further investigation as the results are indicative and are not designed to be definitive. The margin of error associated with 95% control limits is 5%. The 99% control limits (solid red lines) are also presented for information. The funnel plots do not adjust for case-mix so the results should be interpreted with caution.

The funnel plots identified 19 providers as statistical outliers in Apr 2016 to Mar 2017. Of these, 17 were NHS trusts and two were independent sector NHS treatment centres with a total of 21 outliers between them. Eleven NHS trusts were identified as high outliers for the mandatory orthopaedic categories in Apr 2016 to Mar 2017 with an SSI incidence higher than expected, with two trusts being outliers in more than one surgical category. Six NHS trusts and two NHS treatment centres were identified as low outliers in Apr 2016 to Mar 2017. Nine of 19 providers were outliers in the previous year which may indicate ongoing problems with underlying processes.

Although a low outlier may reflect a high standard of infection control practice and surgical skill, other factors should be considered to eliminate methodological bias. For example failure to implement a systematic readmission alert system may miss SSI cases. All high and low outlier trusts have been contacted to make them aware of their outlier status and encouraged to review their practices including their surveillance methodology.

The inpatient/readmission SSI incidence for individual NHS trusts (and participating NHS treatment centres), are published separately as part of this report: https://www.gov.uk/government/publications/surgical-site-infections-ssi-surveillance-nhs-hospitals-in-england
Figure 15: Cumulative incidence of inpatient/readmission SSI plotted against the number of operations by NHS trust and mandatory orthopaedic surgical category, England, Apr 2016 to Mar 2017
7. Hospital perspectives

In September 2017, PHE emailed all participating hospitals offering them an opportunity to submit a short piece describing their experience of SSI surveillance including how they used surveillance to change practice. This chapter presents a selection of examples contributed by hospitals where they describe their own experiences with SSI surveillance and initiatives undertaken to prevent or reduce the SSI incidence at local level.

Royal National Orthopaedic Hospital NHS Trust

At RNOH we are delighted to participate in the Public Health England (PHE) mandatory surveillance for hip and knee replacements as well as the non-mandatory spinal surgery (alongside internal surveillance for amputation, shoulder and elbow categories).

The PHE recommended target response rate for Post Discharge Questionnaire (PDQ) is 70% following surgery for SSI surveillance. All RNOH patients for the listed categories are mailed a PDQ letter to be completed at 30 days post-operatively.

Since December 2015, we implemented weekly telephone follow-ups for unreturned PDQ or patients who have raised concerns through the returned PDQ. The aim of the telephone follow-ups hasn’t just been to increase the PDQ response rate, which it did up to above 80% from July 2016, but also to enable us to identify those patients with delay in their wound healing and subsequently initiate prompt clinical review by the surgical team or arthroplasty nurses in order to prevent further infections, readmission, unnecessary antibiotics prescription in relation to antimicrobial stewardship.

The process of PDQ and telephone follow-up has also helped RNOH patients to get the expert advice from their consultants when needed and all confirmed SSIs by the Consultant following clinical review of evidence are then reported to PHE as per protocol.

Chinedu Onwubuya, SSI Coordinator / Admin Support
Our hospital requested Public Health England (PHE) analysis to examine the risk of SSI between males and females following cardiac and coronary artery bypass graft surgery. Over a five year period (2012 – 2016, last quarter 2016 provisional data), the overall SSI risk was 3.5% for females and for males it was 2.7%.

Female gender is an independent risk factor (for the majority of the population), so our intervention was to reduce the lateral tension on central incision by providing appropriate support wear, specifically designed for cardiac surgery.

Cardiac patients are likely to have longer intubation time and co-morbidities (such as chronic obstructive pulmonary disease) which makes respiratory comfort an important consideration. We avoided a compression style typically used in breast surgery which more likely to ‘press down’ on chest. Side panels on the BHIS™ bra do not compete with a pressure applied over (across/on top) of the breasts, thus respiratory effort and the garment’s ability to accommodate additional fluid weight (associated with cardiac surgery) are not impeded.

We performed a quasi-randomised, retrospective propensity score matched analysis to adjustment for non-random bra assignment [13]. Our data showed the risk of SSI was 1.7 times greater in female patients using a standard compression style bra (i.e. as used in breast surgery) compared to those with a BHIS bra.

Melissa Rochon, Quality and Safety Lead for Surveillance
8. Discussion

8.1 Summary of findings in Apr 2016 to Mar 2017

Overall, a total of 201 NHS hospitals representing 142 NHS trusts and an additional eight Independent Sector (IS) NHS treatment centres participated in Apr 2016 to Mar 2017, (all surgical categories). There was a 4% increase in the number of procedures submitted for orthopaedic categories, compared to Apr 2015 to Mar 2016. However, there was a 5% decrease in the number of procedures submitted for non-orthopaedic surgery. The increase in orthopaedic surgery is encouraging and in line with new NICE quality standards for HCAI surveillance, although surveillance in non-orthopaedic surgery is just as important as tackling infections in the mandatory categories [14].

Data quality was high for most of the key data items in Apr 2016 to Mar 2017 although further improvements in the completion of ASA score and BMI data would enhance the interpretative value of the data. In Apr 2016 to Mar 2017, BMI data completion of 50% or more of submitted records was observed in eight surgical categories. The proportion of patients that were obese was high in a number of surgical categories surveyed. If obesity levels in the population continue to rise this will increase the propensity for diseases such as osteoarthritis or coronary heart disease, increasing the need for surgery. This will increasingly contribute to the total burden of SSI given the impact of elevated BMI on risk of patients developing an SSI [15;16].

The incidence following hip and knee prosthesis remained low in Apr 2016 to Mar 2017 (<1%) and comparable with other European estimates [17]. Despite the low incidence observed in England, it was encouraging to see stable trends in hip prosthesis in the last three successive years. It remains to be seen whether this trend will continue or decrease further. The decreasing trend following repair of neck of femur continued in Apr 2016 to Mar 2017. Although no discernible trends in SSI could be determined for patients undergoing reduction of long bone fracture, a considerable reduction was observed in the last 2 successive years leading to a significant reduction from the baseline in Apr 2009 to Mar 2010.

Among the voluntary-based surgical categories, spanning gastrointestinal, cardiac, vascular, gynaecology, neurology and other general surgery procedures, inter-year variations in the SSI incidence were observed. A significant decrease was found for CABG surgery based on a comparison of the odds of SSI in Apr 2016 to Mar 2017 with the odds in Apr 2009 to Mar 2010 (baseline year). However, an increasing trend was identified for spinal and cholecystectomy surgery. The increase for cholecystectomy may reflect an incremental shift in the pool of surgical patients with serious conditions requiring open surgery (as opposed to laparoscopic surgery which are excluded from...
the surveillance). A borderline decrease was found for cardiac-non-CABG surgery and although not conclusive this cannot be rejected in order to allow further study. Further investigations are needed to explain the trends in these categories.

8.2 Variation in the SSI incidence between participating hospitals

Analysis of data continues to show inter-hospital variation in the SSI incidence for some surgical categories. This suggests that more can be done to reduce this variation by implementing a range of interventions described by some hospitals earlier in this report.

Variation in the SSI incidence between hospitals or within hospitals provides a trigger for investigating possible causes and identifying ways of reducing the SSI incidence. PHE undertakes quarterly outlier detection to ensure hospitals are aware of their elevated risk and works in partnership with high outlier hospitals to assist them with further investigations. Hospitals identified as low outliers are also alerted so that they can investigate their case ascertainment methods.

The use of reports available from the web-based application allows hospitals to risk-stratify elevated SSI risk to determine whether differences in case-mix or operation-related factors can explain some of the variation. Auditing clinical practice against NICE’s quality standards for SSI, comprising a simple evidence-based checklist of pre, peri-operative and post-operative interventions, provides an opportunity for hospitals to optimise clinical practices as a means of reducing or preventing SSIs [18]. The quality standards, based on the NICE SSI prevention guidelines, cover, normothermia, skin asepsis and surgical antibiotic prophylaxis (choice, timing of agent, frequency and dose) [8]. The guidelines on surgical antimicrobial prophylaxis are an additional resource with similar recommendations based on a review of the evidence [9]. New WHO guidelines on the prevention of SSI are also available providing a standardised approach to pre, peri and post-operative measures whilst addressing previous gaps in knowledge [19;20]. The experience shared by the hospitals in Chapter 7 provides an opportunity for other hospitals to learn what interventions have worked for others in preventing SSIs.

8.3 Microbial aetiology

A markedly decreasing trend in *S. aureus* as a reported cause of SSI has been occurring since Apr 2006 to Mar 2007. These trends have continued into Apr 2016 to Mar 2017. The decreasing trend in *S. aureus* SSIs is likely to be explained by the marked reductions in MRSA SSIs, also occurring since Apr 2006 to Mar 2007. In Apr 2016 to Mar 2017, MRSA accounted for 2% of SSIs reducing further from Apr 2015 to Mar 2016. It remains to be seen whether this trend will persist. The reduction in MRSA is likely to reflect the impact of infection control initiatives directed at controlling MRSA of which pre-admission screening and decolonisation of carriers represents an important component [21].
MSSA decreased over the last 4 successive years stabilising to 9% of cases in Apr 2015 to Mar 2016 and Apr 2016 to Mar 2017. It remains to be seen whether further decreases will occur. Nevertheless, dual reductions in the methicillin resistant and susceptible forms of \textit{S. aureus} are encouraging as these contribute to reductions in overall \textit{S. aureus}. Enterobacteriaceae as reported causes of SSIs had been increasing since April 2008 to March 2009, accounting for 29% of SSIs by Apr 2016 to Mar 2017, the highest to date.

The trends in MRSA and Enterobacteriaceae SSIs have been modelled and found to be significant, with the increase in Enterobacteriaceae raising particular concern in the context of increased antibiotic resistance in these pathogens [22]. Initiatives to reduce Gram-negative infections are now a major focus of national activity [23].

At surgical-category level, data for Apr 2016 to Mar 2017 showed that among monomicrobial infections, \textit{S. aureus} was the predominant organism in orthopaedic surgery and spinal surgery. CoNS were the predominant organisms in spinal and CABG surgery. In spinal surgery CoNs accounted for a relatively higher proportion compared to previous reports. The organisms in these surgical categories may reflect the use of implants. Enterobacteriaceae were the predominant organisms in large bowel surgery, reflecting the expected organisms at the operative site, but were also significant contributors to infections CABG surgery (29%).

Among polymicrobial infections, Gram-positive and Gram-negative combinations were the most frequent type of infections in three of six surgical categories examined. Although this combination affected a small set of patients, this may have implications for choice of surgical antimicrobial prophylaxis at local level.

The organism distribution by SSI site collected only for organ-space SSIs identified staphylococci and Enterobacteriaceae as generally the most frequent pathogens. However, data quality needs further improvement in terms of collection of organism data in all specialities examined to enhance interpretive value in this subset of infections.

The organism distribution among primary total hip prosthesis infections by fixation group is a novel analysis and provides further useful insights. The burden of \textit{S. aureus} was found to be highest in the uncemented group compared to the cemented and hybrid fixation groups. The cemented group had the highest proportion due to Enterobacteriaceae compared to the other two fixation groups.

Due to recent concern over severe \textit{Mycobacterium chimaera} infections associated with heater-cooler units in cardiothoracic surgery [24-26], guidance has been published by PHE to assist hospitals undertaking cardiac surgery in managing this risk [27]. Hospitals are also asked to report possible \textit{M. chimaera} infections or other members of the
Mycobacteria avium complex (MAC) isolated from clinically significant specimens in patients with a history of cardiopulmonary bypass surgery or extracorporeal membrane oxygenation to their local PHE Health Protection Teams [27]. M. chimaera is a slow growing atypical mycobacterium and most infections associated with heater coolers have arisen more than 1 year after surgery, beyond the follow-up period within the SSISs programme [26]. However, monitoring SSI levels in cardiac patients, especially those undergoing valve repair or replacement, will provide a means to assess risk in these patients from a range of pathogens that could be acquired during surgery. Although the risk of M. chimaera is very small, all patients at highest risk, those who underwent prosthetic valve surgery on bypass, were notified in February–March 2017 of possible symptoms to improve early diagnosis [28]. New guidance was issued for primary and secondary care providers to assist in managing these cases [27].

8.4 Future directions

The SSI web-based application is currently undergoing development to enhance the user experience of data by improving navigation and streamlining the in-built quality assurance process. The new web-application will be launched during 2018 with upgraded functionality and response speed.

Post-discharge questionnaires completed by patients (PDQs) are the most commonly used of the optional post-discharge methods and offer a comprehensive way of collecting data. However, before PDQ data can be included in a benchmark an effective means to improve uptake by hospitals and completion by patients is needed. To support continuous improvement in SSI surveillance, including reducing the hospital resources needed to run the surveillance, PHE are in the process of developing an electronic PDQ system as an extension to the existing SSISs system. This should enhance the ease of data collection, both for patients and healthcare workers, as well as improving the quality and timeliness of data collection by boosting PDQ return rates. In turn, these more consistent data could be used to derive a national benchmark.
9. Glossary

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

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, 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.

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.

Confidence interval and control limits
The 95% confidence interval (exact binomial for proportions and exact Poisson for the incidence density) provides a guide to the precision of the estimate based on the number of procedures (or days of follow-up) surveyed from participating hospitals. The calculation does not take into account patient clustering within hospitals. Given the level of confidence, the interval indicates that the ‘true’ incidence' could lie anywhere between the lower and higher confidence limits. Control limits (CL) used in funnel plots are equivalent to exact binomial confidence limits at 95% (warning) and 99% (action). These define the limits of expected variation. The probability of a cumulative incidence lying above the 95% CL by chance alone is less than 5% (there is a 1 in 20 chance that the observed estimate is due to chance alone in a defined period); if above the 99% CLs, this is less than 1%. The 99% control limits also define the limits of expected variation and are computed based on the same ‘sample size; the confidence range is wider but this is offset with a lower margin of error (1%). The 99% control limits are presented for information since the conventional level of significance is 5%.
**P-value**
This measures the probability of an estimate (e.g. a risk) being as or more extreme than that observed in a study population occurring by chance alone if the null hypothesis is true (the assumption that there is no difference between different groups). The significance level for the $P$-value is conventionally set at $\leq 0.05$. This means that we are prepared to accept no more than a 5% chance of being wrong in claiming that our observed result is true. If the p-value around an estimate is $>0.05$, this indicates that the data do not provide sufficient evidence to reject the null hypothesis.

**Odds ratio**
This is the odds or likelihood of an event, for example, an infection in an ‘exposed’ group of subjects compared to another group (‘non-exposed’). An odds ratio (OR) of 1 indicates that there is no difference in the odds of developing an SSI between the two groups. An odds ratio of $>1$ indicates that the odds or likelihood of developing an SSI is greater in the ‘exposed’ group compared to the ‘non-exposed’. An OR of $<1$ indicates that the odds or likelihood of developing an SSI is higher in the ‘non-exposed’ group.
10. References


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