Taking a zero tolerance approach to preventable surgical site infections in UK hospitals
The UK has witnessed dramatic reductions in the rates of Clostridium difficile (C. difficile) and Methicillin-resistant Staphylococcus aureus (MRSA) bloodstream infections since 2006/7, when the health service made a concerted attempt to eradicate avoidable cases of these difficult-to-treat and dangerous healthcare-associated infections (HCAI). Since the mid-2000s, there has been a significant cultural shift in the way UK hospitals tackle infection prevention and control, with the greatest reductions in infection rates seen in hospitals with strong leadership and robust performance management.

Reducing MRSA bloodstream and C. difficile infections has been a top priority for most NHS Trusts, but other types of infection have been relatively neglected. Many hospitals do not undertake routine surveillance on any other HCAIs, and even those that do until recently, then only reported data on MRSA and C. difficile infections.

Surgical site infections (SSIs) impose a substantial burden on both the patient and the healthcare system, yet little is known about the true rates of infection in the UK and the cost of these infections to the NHS. Many SSIs are unaccounted for as the majority (up to 60%) are superficial and present in the community post-discharge. Surveillance reports from the Health Protection Agency (HPA) underestimate the true impact of SSIs as they generally only capture inpatient SSIs whereas significant primary care costs are associated with the treatment of SSIs. What we do know is that patients with SSIs have long unplanned hospital stays; are five-times more likely to be readmitted after discharge, are 60% more likely to spend time in an intensive care unit (ICU), and twice as likely to die as those without SSIs. Healthcare-related costs almost double if a patient suffers an SSI.

The better news is that the vast majority of SSIs are preventable. The patient’s own skin is the source of the pathogens responsible for most SSIs, so a few basic but essential evidence-based practices prior to and during surgery, can significantly reduce SSI rates and, by doing so, improve patient safety, unblock beds, reduce readmissions, and save the NHS a substantial amount of money.

SSIs should be moved up the management and infection prevention and control agenda and we should adopt a zero tolerance approach to these potentially preventable infections. It is our belief that surgical teams that are armed with their own SSI data, have a collective focus supported by their infection control, management and procurement colleagues, and are willing to make a few small changes to their everyday surgical practice, could significantly reduce the burden and cost of SSIs. As has been seen in hospitals like UCLH, removing financial hurdles and adopting a ‘spend to save’ mentality ensures that the best products and practices with the best evidence for their SSI reduction potential are used.

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UK hospitals should take a zero tolerance approach to preventable SSIs

- There should be continuous hospital surveillance and reporting of SSIs
- A nationally-agreed methodology for SSI identification and reporting after discharge must be developed and applied
- Every hospital should review its current practice in relation to the prevention of SSIs
- Evidence-based approaches to the prevention of SSIs must be implemented and complied with by all members of the surgical team
- Hospital-level SSI data should be fed back to the surgical teams on a regular basis, with support for change where rates could improve
- Hospital readmission rates due to SSIs should be monitored and reported
- A formal process for exchanging SSI data and sharing best practice between hospitals should be developed

Overriding all of these points is the need for a cultural and behavioural change of mindset resulting in a collective focus across hospital management, clinical staff, procurement, and infection control teams to minimise SSIs.
SSIs have been relatively neglected in the country-wide quest to reduce rates of C. difficile and MRSA bloodstream infections. It is time to take action and adopt a zero tolerance approach to these preventable, costly and potentially serious infections.

- SSIs can be potentially life-threatening post-operative complications that currently account for around 1 in 7 HCAIs.
- SSIs are estimated to affect at least 5% of patients undergoing a surgical procedure in England and Wales. However, since most hospitals do not undertake routine surveillance on SSIs, and many SSIs present and are managed in the community, it is likely that any estimates based on hospital surveillance are a gross underestimation of the extent of the problem.
- SSIs have a major impact on both the sufferer and healthcare provider. Individuals who develop an SSI typically spend an additional 7–10 days in hospital; they are 60% more likely to spend time in ICU, five times more likely to be readmitted to hospital after discharge, and twice as likely to die as those uninfected after their surgery.
- Healthcare-related costs almost double if a patient suffers an SSI. Conservative estimates suggest that the average cost per SSI to the NHS is approximately £3200, however, some SSIs (e.g. those developing after limb amputation) have been estimated to cost the NHS in excess of £6000 per infection.
- Emerging evidence suggests that the patient’s own skin is the source of most of the pathogens involved in SSIs, suggesting that a greater focus on skin antisepsis may have a substantial impact on infection rates.
- Studies have demonstrated that the incidence of SSIs varies widely between hospitals and between surgeons. Surgical teams that know their SSI rates are often able to reduce them through the implementation of a range of basic, relatively inexpensive infection prevention measures.
- The role of leadership within Trusts in terms of championing SSI reduction cannot be overstated. The importance of HCAI reduction in general has to be driven through all levels of the organisation by these key players. This will be integral to the adoption of best practice and a culture where HCAI avoidance is of paramount importance to patient outcomes.

- The Department of Health [DH] has recently updated its evidence-based High Impact Intervention care bundle for the prevention of SSIs. This includes recommendations for screening and decolonization, skin disinfection, and the use of prophylactic antibiotics and surgical dressings.
- The DH care bundle, for the first time, emphasizes the importance of skin preparation in the prevention of SSIs and now recommends the use of 2% chlorhexidine gluconate and 70% isopropyl alcohol solution, based on a substantial body of evidence suggesting this to be the optimal agent for pre-surgical skin antisepsis.
- Establishing the cost-effectiveness of different infection control strategies or new technologies is challenging, since timely and accurate data on local SSI rates is lacking, there is no formal process to identify or monitor SSIs presenting in primary care, and randomized controlled trials are expensive and often impractical. Nevertheless, ‘headroom’ or ‘threshold’ analyses can be adopted which determine how much can be cost effectively invested in the prevention of an infection. These analyses are largely supportive of greater investment in prevention to avoid the costs of an SSI to the NHS, the wider UK economy and the unnecessary suffering to the patient and their family.

EXECUTIVE SUMMARY

SSIs have been relatively neglected in the country-wide quest to reduce rates of C. difficile and MRSA bloodstream infections. It is time to take action and adopt a zero tolerance approach to these preventable, costly and potentially serious infections.
SSIs: THE SIZE OF THE PROBLEM

SSIs are wound infections that occur after an invasive surgical procedure. They range from a limited wound discharge to a potentially life-threatening post-operative complication such as a sternal infection after open heart surgery. SSIs account for around 1 in 7 HCAIs in acute hospitals in the UK, and are the third most common type of HCAI after urinary tract infections and pneumonia (Figure 1).

The National Institute for Health and Clinical Excellence (NICE) has estimated that approximately 5% of all surgical procedures undertaken in the UK are associated with an SSI. Limb amputations and bowel procedures carry the greatest risk of developing an SSI, however, vascular surgery, gastric surgery and cholecystectomy are all associated with SSI rates in excess of 5% (Table 1). Since the majority of SSIs present in the community post-discharge, it is highly likely that hospital-based surveillance studies significantly underestimate the true extent of the problem.

SSIs have a major impact on both the sufferer and the healthcare provider (Figure 2). Individuals who develop an SSI typically remain in hospital for an additional 7–10 days; they are 60% more likely to spend time in an intensive care unit, five times more likely to be readmitted to hospital once discharged, and twice as likely to die as those uninfected after their surgery. Other poor clinical outcomes associated with SSIs include unsightly scars, persistent pain and itching, restriction of movement – particularly when over joints – and a greatly reduced quality of life.

### Table 1

<table>
<thead>
<tr>
<th>Category</th>
<th>SSI rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal hysterectomy</td>
<td>2.4</td>
</tr>
<tr>
<td>Bile duct, liver, pancreas</td>
<td>12.3</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>5.8</td>
</tr>
<tr>
<td>Gastric surgery</td>
<td>9.7</td>
</tr>
<tr>
<td>CABG</td>
<td>4.3</td>
</tr>
<tr>
<td>Hip prosthesis</td>
<td>3.1</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>1.7</td>
</tr>
<tr>
<td>Limb amputation</td>
<td>15.6</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>7.5</td>
</tr>
</tbody>
</table>

**Figure 1**
Types of HCAI across acute hospitals

**Figure 2**
SSIs impose a substantial burden on the individual and on the healthcare budget.
Infection prevention measures have historically been focused on asepsis of healthcare professionals and the environment. Emerging evidence, however, suggests that the patient’s own skin is the source of most of the pathogens involved in SSIs. Each time the skin is breached, patients are at risk of contamination from their own flora.

Normal skin contains crevices, grooves, hair follicles and sebaceous glands, all of which act as reservoirs for bacterial breeding. A single cm² of skin can harbour as many as a million aerobic bacteria, with the type and density of the micro-organisms determined by anatomical location, local humidity, and the amount of sebum and sweat produced, as well as host factors such as hormonal status and age.

The Health Protection Agency has recently reported that staphylococci are by far the most common cause of SSIs in the UK, accounting for almost 50% of the micro-organisms responsible for SSIs (Figure 3). Staphylococcus aureus, which is a normal component of human nasal microflora, can lead to serious invasive infections such as septic arthritis, osteomyelitis, pneumonia, mediastinitis, meningitis, septicæmia and endocarditis. Staphylococcus epidermidis, which is the most common organism found on the skin, has emerged as a frequent cause of HCAIs and is particularly pathogenic in immunocompromised individuals such as those receiving immunosuppressive therapies, neonates and patients with indwelling devices and prosthetic implants.

Since skin-dwelling bacteria such as staphylococci are an important cause of SSIs – even in patients undergoing contaminated procedures such as colorectal surgery – it is imperative that skin antisepsis is optimised before surgery.
Many factors have been identified that contribute to the risk of SSIs; some of them are modifiable while others are not (Figure 4). Increasing age, underlying medical conditions, obesity and smoking have all been shown to increase the risk of SSIs\(^1\). More complex surgical procedures and prolonged operations are also considered important risk factors\(^1\), as are the number and virulence of micro-organisms present on the skin\(^3\).

Studies have demonstrated that the incidence of SSIs varies widely between hospitals and between surgeons\(^1\), suggesting that working practices play a critical role in the prevention of these infections. Surgical teams that are equipped with their post-operative infection data are often able to reduce their surgical site infection rates\(^3\), suggesting that more could be done to improve infection control in routine surgical practice. Unfortunately, many UK hospitals do not routinely collect SSI data or provide feedback on SSI rates to the surgical staff, thereby missing vital opportunities to monitor infection rates and assess the outcomes of any changes to infection control practices.

**Evidence-based guidelines for preventing SSIs**

Several evidence-based clinical guidelines have now been produced with the aim of minimizing the risk of SSIs in UK hospitals\(^1,39\). The Department of Health has recently revised its High Impact Intervention care bundle to prevent surgical site infections, and included evidence-based recommendations for pre-operative, intra-operative and post-operative care (Table 2). Unfortunately, studies suggest that compliance with recommended guidelines for prevention of SSIs is often sub-optimal\(^0\), and many operating theatre rituals that are conducted in the name of infection prevention lack any supporting evidence in the literature\(^1\).

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**Figure 4**

Factors contributing to risk of SSI
Estimating the rate of SSIs

There are huge variations in the published literature relating to SSI rates depending on the population being studied, the types of surgical intervention, the definitions used, the surveillance approaches taken, and the time periods over which rates are measured. We also know that many SSIs are unaccounted for as the majority (up to 60%) are superficial and present in the community post-discharge. Surveillance reports from the Health Protection Agency (HPA) underestimate the true impact of SSIs. In their review of SSI rates in Europe, Leaper et al. established health economic arguments in relation to the burden of SSIs and the potential costs and benefits associated with their reduction requires the use of accurate and timely estimates of local infection rates, the cost of those infections and good quality data generated from randomized controlled trials on the effectiveness of different strategies or new technologies. This, unfortunately, is not as easy as it may seem.

Table 2.
Department of Health’s High Impact Intervention No. 4 – care bundle to prevent surgical site infection.18

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRE-OPERATIVE PHASE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Screening and decolonization</td>
<td>- Patient has been screened for MRSA using local guidelines. If found positive they have been decolonized according to the recommended protocol prior to surgery</td>
</tr>
<tr>
<td>2. Pre-operative showering</td>
<td>- Patient has showered (or bathed/washed if unable to shower) pre-operatively using soap</td>
</tr>
<tr>
<td>3. Hair removal</td>
<td>- If hair removal is required, it is removed using clippers with a disposable head (not by shaving) and timed as close to the operating procedure as possible</td>
</tr>
<tr>
<td><strong>INTRA-OPERATIVE PHASE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Skin preparation</td>
<td>- Patient’s skin has been prepared with a 2% chlorhexidine gluconate and 70% isopropyl alcohol solution and allowed to air dry. If the patient has sensitivity to this solution, povidone-iodine application should be used</td>
</tr>
<tr>
<td>2. Prophylactic antibiotics</td>
<td>- Appropriate antibiotics were administered within 60 minutes prior to incision and only repeated if there is excessive blood loss, a prolonged operation or during prosthetic surgery</td>
</tr>
<tr>
<td>3. Normothermia</td>
<td>- Body temperature is maintained above 36°C in the peri-operative period</td>
</tr>
<tr>
<td>4. Incise drapes</td>
<td>- If incise drapes are used, they are impregnated with an antiseptic</td>
</tr>
<tr>
<td>5. Supplemented oxygen</td>
<td>- Patients’ haemoglobin saturation is maintained above 95% (or as high as possible if there is underlying respiratory insufficiency) in the intra- and post-operative stages (recovery room)</td>
</tr>
<tr>
<td>6. Glucose control</td>
<td>- A glucose level of ≤11 mmol/L has been maintained in diabetic patients (this tight blood glucose control is not yet considered relevant in non-diabetic patients)</td>
</tr>
<tr>
<td><strong>POST-OPERATIVE PHASE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Surgical dressing</td>
<td>- The wound is covered with an interactive dressing at the end of surgery and while the wound is healing</td>
</tr>
<tr>
<td></td>
<td>- Interactive wound dressing is kept undisturbed for a minimum of 48 hours after surgery unless there is leakage from the dressing and need for a change</td>
</tr>
<tr>
<td></td>
<td>- The principles of asepsis (non-touch technique) are used when the wound is being re-dressed</td>
</tr>
<tr>
<td>2. Hand hygiene</td>
<td>- Hands are decontaminated immediately before and after each episode of patient contact using the correct hand hygiene technique [use of the WHO’s ‘5 moments of hand hygiene’ or NPSA ‘Clean your hands’ campaign is recommended]</td>
</tr>
</tbody>
</table>
(2004) reported rate variations ranging from 1.5% to 20%, with 1.1–2.8% of ‘clean’ surgeries and 2.6–20% of ‘dirty’ surgeries associated with an SSI. Coello et al (2005) reported an SSI rate of 4.2% across more than 67,000 surgical procedures undertaken in the UK between October 1997 and June 2001, with rates as low as 1.9% for knee prostheses and as high as 14.3% for limb amputations. In its 2008 surgical site infection clinical guideline, NICE estimated that at least 5% of all surgical procedures undertaken in the UK are associated with a SSI.

### Estimating the cost of SSIs

In their seminal work on the socio-economic burden of hospital-acquired infections, Plowman et al (2000) estimated that the average cost per SSI to the NHS was approximately £1600 (1995–1996 costs). The majority of these costs result from incremental days spent in hospital, with both Coello et al and Leaper et al estimating an average incremental length of stay of approximately 10 days per SSI (Table 4). This translates into an average cost per SSI of approximately £3200 (2010 costs), although estimated SSI costs have ranged from £814 for abdominal hysterectomy to £6161 for limb amputation (Table 4). Using an average cost of ~£3,500 per infection, it has been estimated that SSIs currently cost the NHS in the region of £700 million per year. If one were to adopt a more conservative estimate of the cost of treating infections of £800, at the lower end of the range reported by Coello et al, then this would still equate to a cost of around £160 million per annum.

Studies such as these rarely account for the cost of primary care consultations and the many SSIs that are managed outside the hospital setting. Neither do they account for the cost to the patient or to society as whole for the loss of income or work productivity associated with extended hospital stays and subsequent morbidities. Opportunity costs associated with ‘bed blocking’, the cancelled admissions of other patients, and the cost of readmitting patients with an SSI are also not factored into these figures, suggesting that the estimated total cost of SSIs based on the studies outlined above are no more than just the ‘tip of the iceberg’.

### Estimating the effectiveness of management strategies

There are significant difficulties associated with undertaking controlled clinical trials of different management strategies or new technologies in the prevention of SSIs. Large sample sizes are needed for randomized controlled studies, requiring the involvement of multiple study centres, which makes controlling for confounding practices extremely difficult. ‘Headroom’ or ‘threshold’ economic approaches are often used in the absence of robust effectiveness data, whereby an estimate is made of how effective a strategy would need to be in order to break even or save money. The approach is illustrated below.

#### Example of ‘headroom’ approach: application to a hypothetical hospital

- **Number of procedures conducted per annum which present a risk of SSI = 10,000**
- **Rate of surgical site infections = 5%**
- **Estimated cost of surgical site infections = £3,500**

### Burden of SSI to the hospital

**Expected number of SSIs = 500**

**Estimated total cost to the hospital = £1,750,000**

- **Assume a new technology to help prevent the incidence of SSI is made available at a cost of £10 per procedure. If this were used in all surgical procedures then the cost to the hospital = £100,000**
- **To break even, the hospital would need to reduce the number of infections by 29 (derived from the additional cost of technology, £100,000, divided by the cost of an infection, £3,500)**
- **This equates to reducing the rate of infection from 5% to 4.71%. Put another way, this also equates to an absolute risk reduction of 0.29% or a relative risk reduction of 5.8%.”

SSIs are costly to the NHS with healthcare-related costs almost doubling if a patient suffers an SSI and yet they are relatively low in cost to prevent. ‘Headroom’ or ‘threshold’ analyses can be adopted which determine how much can be cost effectively invested in the prevention of an infection. These analyses are largely supportive of greater investment in prevention to avoid the costs of an SSI to the NHS and the unnecessary suffering to the patient.

<table>
<thead>
<tr>
<th>Surgical procedure</th>
<th>Extra length of stay</th>
<th>Extra cost per SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limb amputation</td>
<td>21.2 days</td>
<td>£6161</td>
</tr>
<tr>
<td>Small bowel surgery</td>
<td>12.9 days</td>
<td>£3313</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>11.4 days</td>
<td>£3749</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>10.8 days</td>
<td>£3138</td>
</tr>
<tr>
<td>Hip prosthesis</td>
<td>8.9 days</td>
<td>£2586</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>8.6 days</td>
<td>£2499</td>
</tr>
<tr>
<td>Open reduction of long bone fracture</td>
<td>8.4 days</td>
<td>£2441</td>
</tr>
<tr>
<td>Large bowel surgery</td>
<td>7.8 days</td>
<td>£2267</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>2.8 days</td>
<td>£814</td>
</tr>
</tbody>
</table>

#### Table 4

Even with superficial SSIs the costs can be substantial.
The **Wolverhampton Heart and Lung Centre** is one of the busiest cardiac surgery units in the West Midlands. It was the first purpose-built integrated cardiac unit in the UK and, since opening in 2004, has conducted more than 5200 cardiac operations – an average of 864 operations each year. The Centre has an active and ongoing infection surveillance programme and it collects and reports SSI data to the Health Protection Agency (HPA) every quarter.

In 2006, after relatively stable SSI rates of around 2%, rates increased significantly during two consecutive quarters (Figure 5). No obvious pattern of infection could be identified in terms of surgical or scrub teams, theatre use or microorganisms involved. A detailed audit of all CABG patients over 1 year (N=540) was therefore undertaken using logistical regression analysis of over 50 pre-operative and intra-operative variables captured in the hospital’s database, and four independent risk factors for SSIs emerged: non-elective surgery, peripheral vascular disease, chronic obstructive pulmonary disease (COPD) and renal dysfunction.

The latter three factors cannot be modulated easily, but it was postulated that as patients undergoing non-elective surgery were frequently in hospital for a week or longer prior to their operation, their skin colonization may have altered unfavourably with “hospital-acquired” micro-organisms. This prompted a range of evidence-based procedural changes aimed at prevention of SSIs by improving skin preparation. Changes implemented included:

- Improved patient preparation
  - With a greater focus on social hygiene
  - With antiseptic showers on the morning of surgery and the night before if possible
- Improved skin preparation and protection measures
  - Consultant-led prep procedure
  - Additional initial prep with chlorhexidine in the anaesthetic room
  - Increased drying time
  - More glove changes
- Increased use of barrier drapes
  - Antibiotic-impregnated drapes for chest
  - Additional drapes used for legs
- Isolation of operative sites
  - No interchange of instruments
  - Additional separating drapes

**Results:** A rapid decrease in SSI rates was evident (Figure 5), with a return to baseline levels in the two quarters subsequent to the infection control changes. Levels have remained stable and low since the changes have been implemented.

With thanks to **Mr Moninder Bhabra**, Cardiothoracic Surgeon, Wolverhampton Heart and Lung Centre, New Cross Hospital, Wolverhampton, West Midlands for providing the information for this case study.
The **University College London Hospitals NHS Foundation Trust** (UCLH), situated in the heart of London, is one of the most complex NHS Trusts in the UK, serving a large and diverse population. The Trust provides acute and specialist services, and, in 2010, had contracts with more than 150 Primary Care Trusts. The hospitals that make up the trust, which include University College Hospital, the National Hospital for Neurology and Neurosurgery and the Heart Hospital, see over 500,000 outpatients and admit over 100,000 patients each year.

Since 2000, over the past 10 years, projects have been initiated with the aim of reducing SSIs across the Trust. A range of new products, procedures and changes to surgical practice were introduced (Figure 6) in consultation with key stakeholders such as the infection control and microbiology departments, clinical users, the procurement department, commercial partners and the purchasing hub.

A SSI prevention bundle was implemented, CVC/procedure packs were developed, and new products including catheter securing devices, Chloraprep pre-operative skin antiseptic, advanced dressings and needle-free access devices were introduced. Having a ‘spend to save’ mentality ensured that the best products with the best evidence for their SSI reduction potential were introduced, with infection control kept high on the Trust’s agenda throughout that period decade. Our experience highlighted the importance of the role of the DIPC and team as clinical leaders and drivers in the early stages, as well as leadership from the Chief Executive and Chief Nurse resulting in the promulgation of a culture where the reduction of HCAI is always a priority. The role of the Chief Executive and Chief Nurse within the Trust in terms of championing SSI reduction cannot be overstated. The importance of HCAI reduction in general was driven through all levels of the organisation by these key players. The holding to account of Divisional/General Managers, Medical Directors and Departmental Sisters/Charge Nurses was integral to the adoption of best practice and a culture where HCAI avoidance was of paramount importance to patient outcomes.

**Results:** A dramatic, 10-fold reduction in all bacteraemias has been achieved since 2000 (Figure 6). The project is ongoing and SSI rates remain low.

With thanks to **Mr Phil Adams-Howell**, UCLH Clinical Procurement Lead, University College London Hospitals NHS Trust Headquarters, London, for providing the information for this case study.