The epidemiology of orthopaedic surgical site infection occurring up to one year after surgery: a feasibility study of telephone screening and direct observation by trained healthcare workers

Final Report

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

Surgical site infections (SSI), also referred to as infections of the surgical wound, are one of the most common healthcare associated infections (HAI), accounting for 15.9% of all HAI which cost the National Health Service (NHS) in Scotland £183 million per year[1]. The current SSI surveillance programme in Scotland is conducted as per the national SSI surveillance protocol (http://www.hps.scot.nhs.uk/haiic/sshaip), using standard Center for Disease Control (CDC) definitions for SSI[2]. The current SSI surveillance programme monitors orthopaedic patients from the date of admission until day 30 post operatively (inpatient and readmission surveillance). An SSI is considered healthcare associated if it occurs within one year of surgery if an implant is *in situ*[3].The overall incidence of inpatient SSI reported in Scotland for hip and knee arthroplasty procedures was 1.1% and 0.3% respectively for 2006, and 0.8% and 0.3% respectively for 2009. Although at a population level the inpatient incidence is low, these infections can have serious consequences at the individual patient level in terms of: increased length of stay, pain, suffering, possible further surgical intervention, prolonged antibiotic therapy and cost implications[4] for NHS Scotland. SSI is therefore an important outcome measure for orthopaedic surgical procedures.

The Scottish Surveillance of Healthcare Associated Infection Programme (SSHAIP), within Health Protection Scotland (HPS), facilitates SSI surveillance that is mandatory in all NHS Boards in Scotland. In 2001 Health Department Letter (HDL) (57) 2001 stated that all NHS Boards should collect data on SSI following two categories of surgical procedure, one of which should be orthopaedic[5]. The protocol from this programme encourages NHS Boards to develop programmes of post discharge surveillance (PDS) of SSI utilising a method of direct observation of the patient as this is recognised as being the most reliable and valid way of detecting infection. In 2006, a revised HDL (38) 2006 stated that as of the 1st January 2007 all NHS Boards in Scotland were required to collect data on hip arthroplasty procedures[6]. The HDL requires that PDS should be undertaken using prospective readmission data, up to 30 days following discharge on all hip arthroplasty surgical procedures under surveillance.

Average length of stay in NHS Scotland is steadily decreasing[7], as a result of this; fewer SSIs are detected during the inpatient stay. Unlike inpatient surveillance for SSI there is currently no standard methodology for PDS. Previous literature suggests that up to 84% of SSI may occur following discharge from hospital and as post operative length of stay has decreased many of these infections occur in the community[8]. PDS is considered costly[9-11] and methods adopted vary substantially in terms of their vigour and cost. The validity of SSI rates produced using PDS is influenced by a number of factors including: the length of the follow up period and the seniority, training and experience of the staff collecting the data and rates reported may be subject to inter-rater variation and bias[12]. Within the literature there have been various reported methods for PDS which include patient questionnaires, telephone interviews and retrospective medical record reviews[13-15].

PDS would ideally be achieved by direct observation of the wound after discharge carried out by staff who routinely see the patient in the course of normal clinical care. This is potentially more easily achieved with procedures such as caesarean section and breast surgery, where community midwives and breast care nurse specialists respectively, routinely see the patients for up to 30 days following surgery. Patients having other procedures, such as orthopaedic implant procedures, are not routinely seen post operatively within 30 days and follow up of patients by health care workers for surveillance purposes is considered costly[15]. These procedures have further complexity in terms of follow up as an orthopaedic implant SSI may occur a considerable time following surgery[15]. In a study that used combined methods of telephone and direct observation it was reported that patients themselves were able to diagnose 90% of SSIs with 76% specificity[16].

The Scottish Government Health Department (SGHD) funded HPS to develop methods for PDS in Scotland following orthopaedic procedures. HPS set up a study to examine infections occurring up to one year following orthopaedic implant surgery in order that policy for NHS Scotland could be informed. This study was a joint collaboration between HPS and NHS Highland in order to estimate the epidemiology of orthopaedic SSI occurring up to one year after surgery and to examine the feasibility of telephone screening and direct observation by trained healthcare workers. Study nurses from Raigmore Hospital were trained by members of the SSHAIP team as validation nurses in order to carry out data collection requirements for the study. This final report presents results from the study carried out from 01/03/06 until 28/02/08.

2 NHS Highland Demographics

NHS Highland is responsible for a population of around 310,500 people and covers a land area of approximately 32,518 km². NHS Highland has one district general hospital in Inverness, Raigmore Hospital, and three rural general hospitals in Wick, Fort William and Oban, as well as a number of community hospitals across the area[17].

Raigmore Hospital is an acute general hospital. There is a ward block of eight floors. These include teaching facilities, a theatre suite of nine operating theatres of which two are orthopaedic, all of which have dedicated staff, a six bed intensive care unit, a six bed coronary care unit, a maternity unit, chest/control of infection unit and a renal unit, these are serviced by comprehensive support services. The hospital has a total of 577 beds and employs approximately 3,500 staff.

3 Aims

1. To estimate the incidence of orthopaedic SSI occurring within one year of surgery.
2. To test the validity of telephone surveillance of SSI occurring within one year of surgery.
3. To undertake an economic analysis of this approach to PDS.

4 Methods and Sampling

4.1 Sampling

All patients who underwent elective hip arthroplasty and knee arthroplasty within Raigmore Hospital were included if they met the following inclusion criteria and did not have any of the exclusion criteria:

Inclusions:

Patients who:

- Had a telephone number that was contactable
- Were able to answer the telephone and speak to the study nurses
- Were from the NHS Highlands catchment area

Exclusions:

- Patients with no telephone
- Patients with inappropriate Abbreviated Mental Test (AMT) score (<=5 out of a possible 10 which indicates confusion and the inability to give consent)
- Patients deemed profoundly deaf
- Patients in nursing homes, unless they had access to a phone (Trained carers could not speak on behalf of patients)
- Patients who had undergone emergency procedures
- Patients who were inpatients during the study period (These patients were included in the routine mandatory inpatient surveillance programme)

4.2 Methods

This was a prospective cohort study utilising the current national SSHAIP inpatient model of SSI surveillance which was further expanded to include PDS of SSI. Patients who were identified as having had elective hip or knee arthroplasty procedures were approached by the study nurses during their inpatient stay and asked to consent to participate in the study following an explanation of the aims and requirements of the study. At this point contact details for patients who gave consent to participate were obtained by the study nurses.

Following discharge from hospital patients were telephoned by the study nurse on day 15 post operatively, day 30 post operatively and on a monthly basis until 12 months post operatively, i.e. a total of 13 assessments. During these assessments patients were asked questions regarding the state of their wounds using a standard telephone interview schedule (Appendix 1). Those patients who identified wound problems had their wound directly observed by the study nurse in order to determine whether infection was present according to the case definition (Appendix 2), this information was recorded on a validation form (Appendix 3) and then added to the study database.

Validation was performed on 49% of patients who had reported no wound problems, patients were randomly selected by the study database and these patients were visited by the study nurse to confirm that no infection was present. Each time a patient was contacted by telephone or had a validation visit from the study nurse a record was added to the bespoke study database held on site. On a monthly basis these data were exported to the SSHAIP team at HPS and were appended onto the main study database held within HPS.

Quality assurance of data was carried out within NHS Highlands prior to data export and on receipt at HPS with the following methods:

At Raigmore:

- Records were checked for completeness by the study nurses
- Records were checked for accuracy (i.e. that the operation category matched the operative procedure, that the patient number was correct and that dates were accurate)
- Denominator checks were routinely carried out to ensure all patients who met the study inclusion criteria were included

At HPS:

- Records were checked for completeness and missing data issues were referred to the Raigmore Hospital study nurses
- Standard queries were run within the database on a monthly basis
- Following quality checks/queries by the SSHAIP team at HPS all incomplete data were returned to Raigmore Hospital study nurses
- Records that continued to have key missing data were excluded from the study

A flowchart of the research methods is given on the following page.

Flowchart of research methods:

Inpatient data collection was completed and patients were recruited to the study.

↓

Patients were telephoned on day 15 post operatively. A standard telephone interview schedule was then completed.

↓

Patients reporting wound problems at day 15 had their wounds checked for validation purposes by the study nurse. A standard validation form was then completed.

↓

Patients were telephoned again at day 30. All patients reporting wound problems on day 30 had their wound checked for validation purposes by the study nurse.

↓

Patients were then telephoned monthly for 11 months. Patients reporting wound problems at any review period had their wound checked for validation purposes by the study nurse.

↓

10% of patients who stated they had no wound problems were randomly selected to have their wound checked for validation purposes by the study nurse at each of the study telephone follow up times post operatively.

↓

Patients with a confirmed infection at the previous review period had their wound checked for validation purposes by the study nurse at the next review period.

↓

Data was collated and managed within NHS Highland and then exported to HPS for quality assurance and analyses.

4.3 Methods for economic analysis

An economic analysis involves three distinct stages. These are the identification of all relevant resource use, its measurement in meaningful units and its valuation[18]. The methods for these will now be discussed in turn.

4.3.1 The identification of all relevant resource use

This was identified as the cost to the hospital in terms of study nurse employment and associated administration costs, telephone calls to patients, travel costs to visit patients and interventions carried out for patients identified with post discharge SSI.

4.3.2 Its measurement in meaningful units

Telephone calls were calculated at the daytime rate specified on the British Telecom website at the time of the study (£0.05 per minute). Travel costs were calculated using the standard user rate within the NHS of £0.38 per mile.

4.3.3 Its valuation

Valuation for the above described units were obtained from the contracts department of the study hospital and BT website for phone calls.

5 Ethics

Patients were informed of the study by the research nurse and consented to participate. Ethical approval was achieved locally by NHS Highland staff. The study was also registered on the HPS research register for research governance purposes.

6 Analysis

The validity of the telephone surveillance method was determined through tests of sensitivity, specificity, positive predictive value and negative predictive value using validation visit results as the gold standard. All confidence intervals quoted are Wilson's approximations to binomial intervals[19]. The significance of any difference in infection rates identified as a result of PDS was assessed using Pearson's chi-squared test of proportions. Data were managed in Access 2000 and analyses were carried out in Intercooled Stata 11.2 for Windows.

7 Results

7.1 Demographics of the study population

Within NHS Highland, all major joint surgery is carried out in the orthopaedic unit at Raigmore Hospital. This department has nine Consultant Orthopaedic Surgeons of which eight perform major joint arthroplasties.

During the period 13th March 2006 until the 28th February 2008, 660 patients were recruited to the on going national mandatory inpatient surveillance programme, of these 22 patients were not enrolled into this study due to the study nurses being unavailable. A total of 87 eligible patients included in the mandatory surveillance programme were excluded from the study. The reasons for patients being excluded from the study were collected by the study nurses and entered onto the database. The majority of exclusions from the study were due to not meeting the specified inclusion criteria (Table 1). Fifteen patients (2.3%) refused to participate and 1.1% (7 patients) died before they could participate. Therefore, a final total of 551 patients were recruited to the study. All patients recruited to the study were followed up for a 12 month period.

Of all the orthopaedic procedures included in the study (n= 551) a total of 13 patients were found to have infections occurring up to one year following surgery. For hip arthroplasty procedures included in the study (n=334) a total of three patients were found to have infections. For knee arthroplasty procedures included in the study (n=217) a total of ten patients were found to have infections.

Table 1: Exclusions from Study

Exclusions	Number of Patients
Lived outside study boundary	25
Declined to take part	15
Died	7
Unable to complete all reviews	7
No telephone	6
Unsuitable for other reason	12
Did not meet inclusion criteria	22
Total	**87**

Figures 1 and 2 shows the age and gender of the patient population for each procedure category.

Figure 1: Number of patients by age and sex for hip arthroplasties

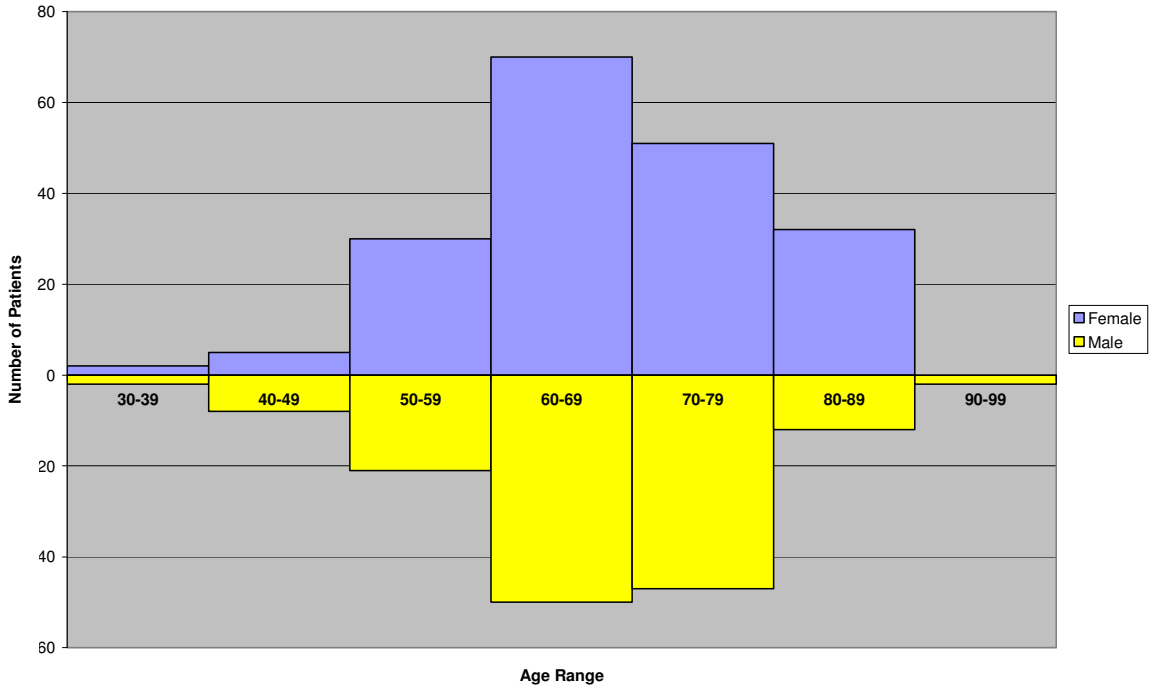
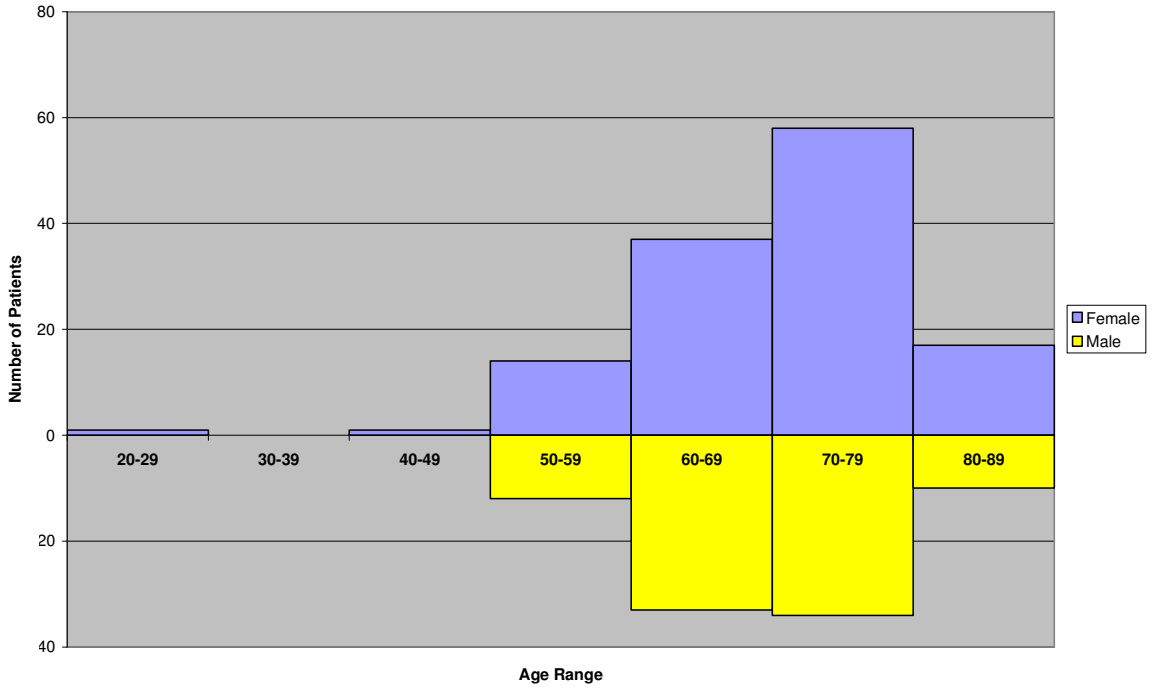


Figure 2: Number of patients by age and sex for knee arthroplasties



The patient group which presented for knee arthroplasty with a median age of 71 (interquartile range 65 to 76) were on average older than those that presented for hip arthroplasty, whose

median age was 68 (interquartile range 61 to 75). The most common age group for hip arthroplasties was 60 to 69 and for knee arthroplasties the most common age group was 70 to 79.

7.2 Incidence of Orthopaedic SSI occurring up to one year following surgery

The inpatient SSI rate was 0.4% (2 SSIs from 551 procedures) and the overall SSI rate was 2.4% (13 of 551 procedures).

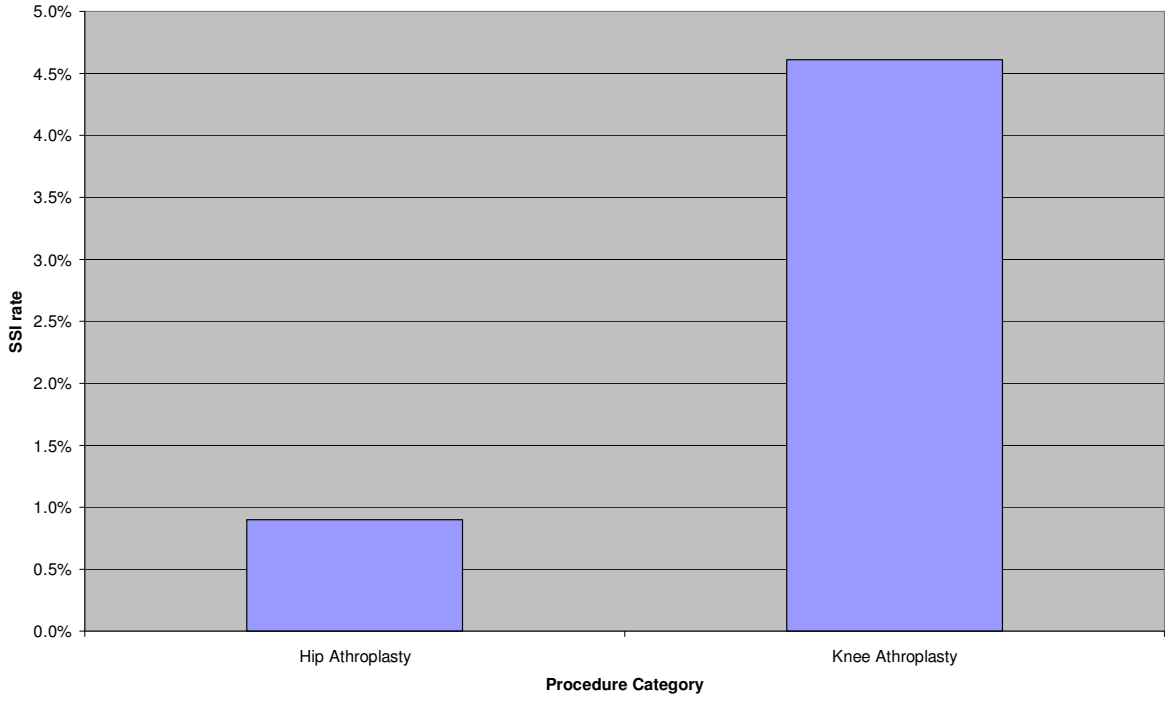
Table 2 shows the total number of procedures overall and by procedure category along with the number of SSIs detected and SSI rates.

Table 2: Total number of procedures and SSIs detected by procedure category

	Total Number of Procedures	Number of SSIs	SSI Rate (95% CI)
Hip Arthroplasty	334	3	0.9% (0.3% - 2.6%)
Knee Arthroplasty	217	10	4.6% (2.5% - 8.3%)
All Procedures	**551**	**13**	**2.4% (1.4% - 4.0%)**

Figure 3 shows that a higher proportion of patients who had knee replacement procedures developed a SSI than those who had hip replacements (χ^2= 7.8596, df = 1, p = 0.005).

Figure 3: Proportion of SSIs detected by procedure category



The NNIS Risk Score is calculated using three major risk factors (see Appendix 4). One factor is related to the state of health of the patient before surgery (American Society of Anesthesiologists (ASA) classification), and the other two factors relate to the operation itself - wound class (the likelihood of micro organisms being present in the wound at the time of surgery) and the duration of surgery. Patients with a score of 0 are at the lowest risk of developing an SSI while those with a score of 3 have the greatest risk. This stratification enables a more standardised comparison of data. Recent data suggest that the incidence of SSI clearly increases with the number of risk factors present[4]. A total of 7.7% of patients (1 of 13) with an SSI could not be risk adjusted as a result of unrecorded ASA classification. For hip arthroplasty procedures, of the three SSIs detected during the inpatient stay, one patient had a NNIS score of 0, one patient had a NNIS score of 2 and the NNIS score could not be calculated for one patient due to missing data for the components of the score (ASA classification). This may be due to the relatively small number of patients within the higher risk groups in this study.

Figure 4: SSIs detected for patients undergoing knee arthroplasties by NNIS Score

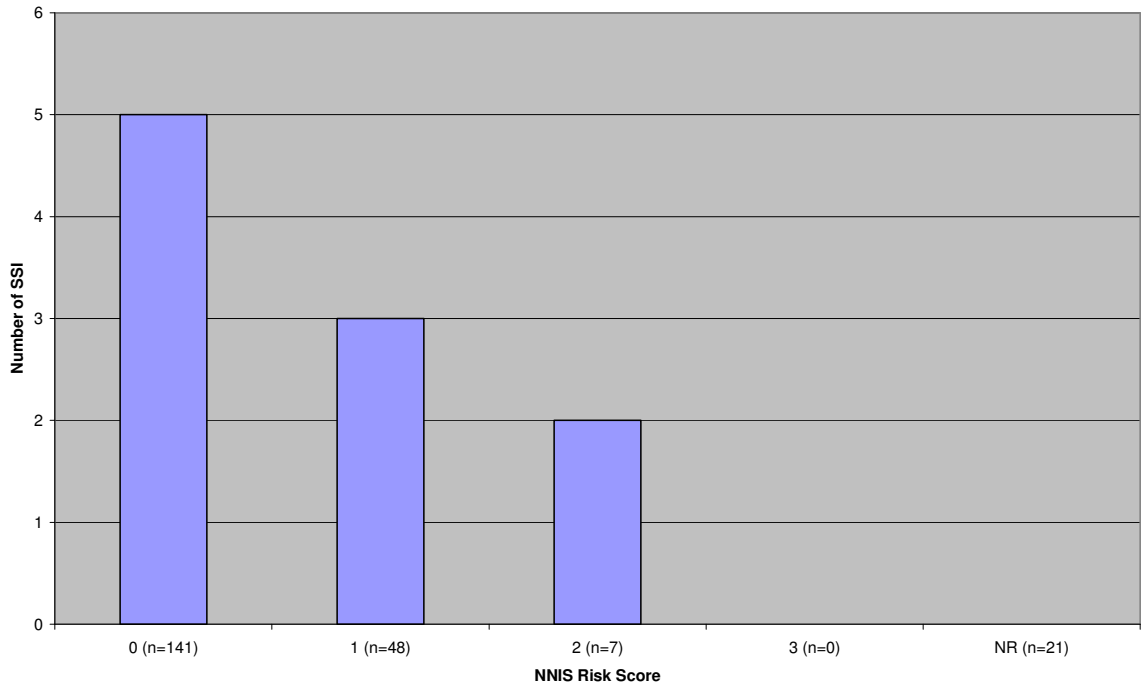


Figure 4 shows the SSIs detected for knee arthroplasty procedures in patients by NNIS score. Of those patients identified as having a SSI, 50.0% had a NNIS risk score of 0; however this group represented 65.0% of all patients undergoing surgery in this study.

Table 3 details: the total number of SSIs validated, the type of SSI and when the infection was identified.

Table 3: SSI type and method of detection

Operation	Type SSI	Detection Method	Detected During Inpatient Episode	Patient Readmitted due to SSI	Detected at which assessment
Hip	Superficial	Inpatient SSI	Yes	No	Before day 15 (as IP)
Hip	Deep	Meets infection criteria	No	Yes	3 months post op
Hip	Superficial	Meets infection criteria	No	Yes	Day 30 post op
Knee	Deep	Meets infection criteria	No	Yes	9 months post op
Knee	Superficial	Meets infection criteria	No	Yes	Day 30 post op
Knee	Organ/Space	Meets infection criteria	No	Yes	Day 30 post op
Knee	Not Recorded	Meets infection criteria	No	Yes	Before day 15
Knee	Organ/Space	Meets infection criteria	No	Yes	Before day 15
Knee	Organ/Space	Meets infection criteria	No	Yes	Day 30 post op
Knee	Organ/Space	Meets infection criteria	No	Yes	2 months post op
Knee	Superficial	Inpatient SSI	Yes	No	Before day 15 (as IP)
Knee	Superficial	Meets infection criteria	No	No	2 months post op
Knee	Superficial	Meets infection criteria	No	No	Before days 15

Two SSIs were detected by the inpatient SSI surveillance programme before the first patient review period on day 15 and one SSI was not detected until 9 months after the date of operation.

Figure 5 displays the time at which the SSIs were first detected for the two procedure categories. The times shown are the points by which an SSI was diagnosed. For example those which are marked day 15 were validated on or before day 15.

Figure 5: Time of SSI detection following hip and knee arthroplasties

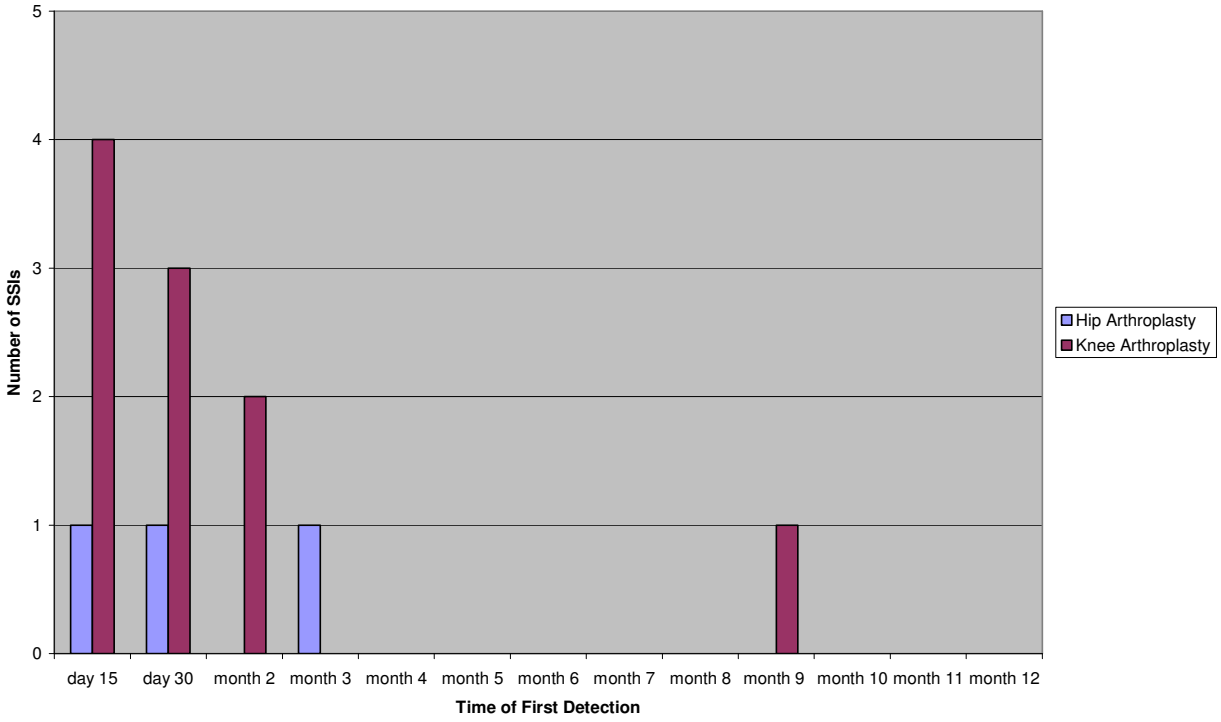


Figure 5 illustrates that two thirds (n=2) of all SSIs detected following hip arthroplasty surgery were confirmed during the 30 day post operative period, with one SSI (33.3%) being detected within three months after surgery. For knee arthroplasties, 70.0% (n=7) of SSIs in this study were detected within 30 days of the operation and 30.0% (n=3) of the SSIs were detected after the 30 day post operative period with one SSI occurring nine months following surgery.

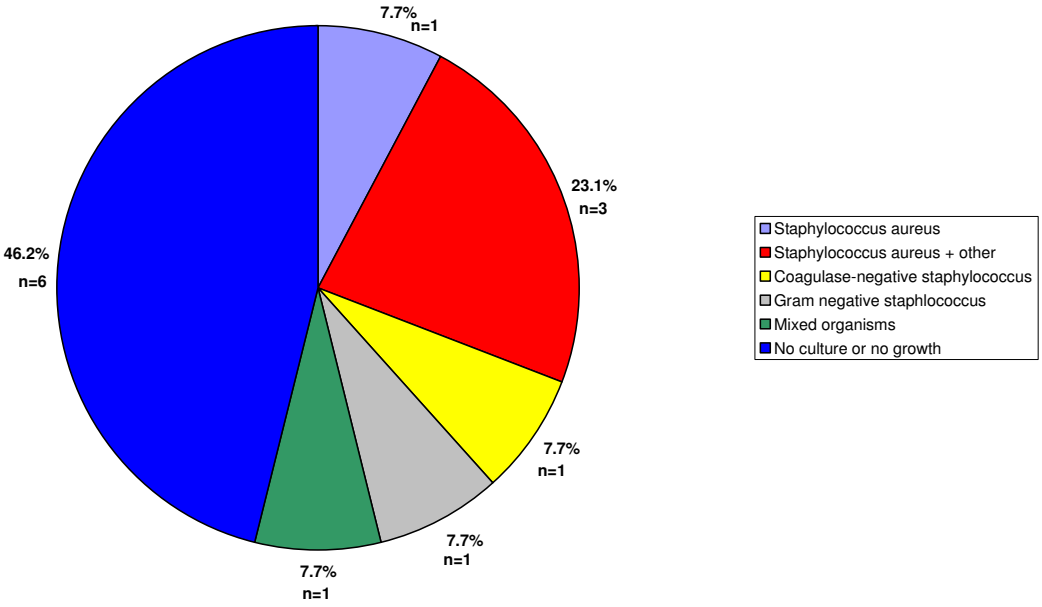
The proportion of all SSIs detected during the inpatient episode was 15.4% (n=2) compared to 53.8% (n=7) after the inpatient episode but within the 30 day post operative period and 30.8% (n=4) after the 30 day post operative period. The infections detected after the 30 day post operative period would not normally be identified by any of the standard surveillance methodologies which generally limit surveillance to 30 post operative days.

Of the 13 SSIs detected in this study, 9 (69.2%) had been resolved by the time of the next validation and four (30.8%) were still present at the time of the next surveillance visit, within a 30 day period. This would suggest that these were mainly superficial infections which were treated effectively once they had been identified.

In 46.2% (n=6) of SSIs either no cultures were obtained or no organisms were grown from the cultures obtained. Data on microorganisms on 53.8% of patients who met the criteria for SSI were obtained. These patients had wound swabs or fluid samples taken from their wounds and sent to

microbiology laboratories for culture. The main organisms identified are listed in Figure 6. Where organisms were identified, *Staphylococcus aureus* was the most commonly reported accounting for 57.1% (n=4) of all reported microorganisms either on its own or in the presence of other organisms.

Figure 6: Organisms isolated from SSI



7.3 Length of Stay (LOS) for Patients

The length of stay for all patients having hip and knee arthroplasties were similar during the study period with hip arthroplasties staying on average 5.9 days compared to an average inpatient stay of 6.6 days for knee arthroplasties. For patients with an SSI:

- the range of LOS was 5 to 14 days
- the mean LOS was 7.3 days
- the median LOS was 7 days

7.4 Validity of Telephone Surveillance

After each surveillance period a randomly selected group of the patients received validation visits after reporting no infection was present during the telephone reviews. In total 342 validation visits were carried out, this represents 62.1% (342 of 551) of all patients within the study.

Only one out of 310 random validations (0.3%) identified a previously unreported SSI. This suggests that almost all SSIs within this patient group were identified through the combination of inpatient surveillance and telephone surveillance presented in this report.

Patients reported infections at 32 different telephone reviews and 12 (37.5%) of these were subsequently confirmed at validation visits. Twenty out of 32 reported infections were therefore found not to meet the infection criteria at validation (Table 4).

Table 4: Comparison of infections found through telephone surveillance and validation visit for all procedures

		Telephone Surveillance		
Validation		Infection	No Infection	Total
	Infection	12	20	32
	No Infection	1	309	310
	Total	**13**	**329**	**342**

A high proportion of patients with SSI and patients without SSI were correctly identified as such by the telephone surveillance system. Out of the 13 SSIs occurring after hip and knee arthroplasty surgery, 12 were identified by the telephone surveillance system. The sensitivity and specificity of the telephone surveillance system were 92.3% and 93.9% respectively. The positive and negative predictive values were 37.5% and 99.7% respectively. The low positive predictive value reflects the low incidence of SSI in the study population.

A breakdown of the results for hip arthroplasties can be found in Table 5.

Table 5: Comparison of infections found through telephone surveillance and validation visit for hip arthroplasties

		Telephone Surveillance		
Validation		Infection	No Infection	Total
	Infection	3	6	9
	No Infection	0	158	158
	Total	**3**	**164**	**167**

All SSIs (n=3) occurring after hip arthroplasty surgery were identified by the telephone surveillance system. The sensitivity and specificity of the telephone surveillance system were 100.0% and

96.3% respectively. The positive and negative predictive values were 33.3% and 100.0% respectively. The low positive predictive value reflects the low incidence of SSI in the study population.

A breakdown of the results for knee arthroplasties can be found in Table 6.

Table 6: Comparison of infections found through telephone surveillance and validation visit for knee arthroplasties

		Telephone Surveillance		
Validation		Infection	No Infection	Total
	Infection	9	14	23
	No Infection	1	151	152
	Total	**10**	**165**	**175**

Of the 10 SSIs occurring following knee arthroplasty surgery, 9 were identified by the telephone surveillance system. The sensitivity and specificity of the telephone surveillance system were 90.0% and 91.5% respectively. The positive and negative predictive values were 39.1% and 99.3% respectively. The low positive predictive value reflects the low incidence of SSI in the study population.

7.5 Economic analysis

In order to evaluate the feasibility and possible practical application of the study methods to wider practice, data on the costs of the study were collected. An analysis of these costs will now be presented. There were three research nurses involved in this study; the following proportion of their working week was dedicated to this study (Table 7).

Table 7: Staff Costs

Time spent on study	Annual Cost
1 x 0.25 WTE Band 7 per year	£7,273
1 x 0.3 WTE Band 7 per year	£8,727
1 x 0.25 WTE Band 5 per year	£5,056
Total annual cost	**£21,056**
Total staff costs for the study (2 years)	**£42,112**

The data collection period for the study was 24 months and therefore staff costs accrued totalled £42,112. Throughout the study period the study research nurses carried out a number of duties including monitoring patients during the inpatient period, conducting telephone reviews, carrying out direct observation of wounds in the patient's home and entering data onto the study database. For the telephone reviews exact details of the time taken to carry out these tasks were collected.

A total of 8680 telephone reviews were carried out at a total duration of 217 hours. The cost of telephone calls totalled £650. No more than four attempted telephone calls were made for each patient.

A total of 8680 reviews were carried out:

- 6214 (71.6%) reviews were carried out on first attempt.
- 1236 (14.2%) reviews were carried out on second attempt
- 443 (5.1%) reviews were carried out on third attempt
- 755 (8.7%) reviews were carried out on fourth attempt
- 32 (0.4%) reviews had no duration or number of attempts recorded by the study nurses

The total time taken for obtaining consent and entering details onto the computer equated to approximately 20 minutes per patient. This involved 15 minutes to obtain consent and 5 minutes for entering the details onto the computer. In total, 660 patients were involved in the study and although not all consented, the time was still taken to explain the study beforehand and all the operations were still recorded.

- The average duration of each review was 1.5 minutes
- The total duration of all telephone calls was 13001 minutes (217 hours)
- The length of telephone calls ranged from 0 to 47 minutes
- The median duration of telephone call was 1.2 minutes

7.6 *Burden Questions*

Table 8: Comparison of the level of burden associated with SSIs

	Patients with SSI
Total number of courses of antibiotics prescribed	17
Total number of District Nurse (DN) visits carried out	8
Total number of times a patient was seen by a General Practitioners (GP)	5
Total number of re operations	1

Seventeen courses of antibiotics were prescribed in the community by GPs for SSI. Four of the patients with SSI received two courses of antibiotics.

Table 9: Total treatment costs for SSIs

Treatment	Cost	No of treatments for SSI	Total Cost
DN Visit	£25.00	8	£200.00
GP Appointment	£30.00	5	£150.00
Re operations	£728.99	1	£728.99
Extra day stay (included antibiotic treatment)	£207.86	111	£23,072.46
Total (2 years)			**£24,151.45**

The average cost per SSI in this study was £24,151.45/13 = £1,857.80

7.7 Validations

A total of 380 validations were carried out which included 342 complete validation visits and 38 validations which were excluded due to incomplete reviews Twenty one of these were carried out instead of a review telephone call because the patients were in hospital for different surgical procedures unrelated to the original operation. On 11 occasions the patient was brought back to Raigmore Hospital for validation. The remaining 348 validations were carried out by visiting the patient's home. The distance travelled to each validation visit was recorded for 274 visits.

- Each validation ranged from one minute to 7.5 hours
- The average duration of validation was 1.3 hours
- The median duration of validation was 40 minutes
- The sum of all validations was 503 hours.

To calculate the cost of validation visits the distance travelled for each validation is required. This calculation can therefore only be done for the 274 visits that had distances recorded.

- The total mileage travelled was 8192.44 miles.
- The average mileage per visit was 29.9 miles.
- The median mileage per visit was 16.1 miles.
- The distance travelled for each visit ranged from 0.08 to 133.84 miles.

The total cost of validation visits was therefore 8192.44 miles at £0.38 per mile = £3113.13

7.8 Total Cost of Surveillance

The breakdown of the cost involved in the undertaking of the study is shown in Table 10.

Table 10: Total cost of the study

ITEM	COST
Staff Salaries	£42112
Telephone Calls	£650
Transport Costs	£3113.13
TOTAL	**£45875.13**

8 Discussion

The aims of this study were:

- To estimate the incidence of orthopaedic SSI occurring within one year of surgery.
- To test the validity of telephone surveillance of SSI occurring within one year of surgery.
- To undertake an economic analysis of this approach to PDS.

Each of these will be discussed in turn.

8.1 Incidence of Orthopaedic SSI Occurring within One Year of Surgery

An overall SSI rate of 2.4% for all orthopaedic SSI occurring within one year of knee and hip arthroplasty was identified in this study. In total, 84.6% of SSIs (n=11) were detected after the inpatient stay, of this total 53.8% were after the inpatient stay but within the 30 day post operative period and 30.8% following the 30 day post operative period and up to nine months.

8.2 Validity of Telephone Surveillance of SSI Occurring within One Year of Surgery

A total of 310 random validation visits were carried out where no SSIs were reported at telephone review. Only one of these visits identified a previously unreported SSI. The negative predictive value for this method is 99.7% which is comparable to similar studies[20]. These findings are consistent with current literature from similar studies that suggest patients are able to reliably identify when they do not have an infection[20].

Patients reported infections at 32 different telephone reviews and 12 of these were subsequently confirmed at validation visits. Therefore 37.5% of infections reported by this method were confirmed by direct observation by a trained healthcare worker. The sensitivity and positive predictive value of the screening method decreases when we consider infections reported by patients as being a positive result. However the number of patients self reporting wound infections were low and in terms of ensuring that accurate numbers of infections are reported these patients should be followed up with direct observation of their wound by a trained healthcare worker.

Telephone surveillance was found to be a highly sensitive and specific method of identifying infection in hip arthroplasties, knee arthroplasties and for orthopaedic surgery as a whole. The low positive predictive values for each procedure category suggests that substantially more patients would require direct observation than the number infected in order to identify the majority of SSIs and this may increase the cost of implementing this methodology. However, even with this concern this methodology appears to be a cost effective alternative to providing validation visits by a trained healthcare worker to all post discharge patients. It is therefore recommended that some form of periodic validation is carried out in order to maintain the quality of these assessments.

8.3 Economic Analysis of this Approach to PDS

The question of the cost effectiveness of PDS for orthopaedic procedures up to a year following surgery is an important point for consideration[21]. This study cost a total of £45875.13 to carry out telephone screening and validation on a total of 551 patients (from a potential cohort of 660 patients). The cost of the study per patient was £83.26. The total infection costs for NHS Highland for patients included in this study was £24,151.45 at a cost of £1,857.80 per patient with SSI.

It has been argued that when increased costs associated with each identified orthopaedic SSI are high then the possibility of prevention through surveillance activities would make PDS up to one year cost effective[22]. However costs associated with this method of PDS were high. Two patients (15.4%) were identified as having an SSI during the inpatient stay and 9 patients (69.2%) were readmitted for an SSI until day 30 post operatively. The current SSI programme requires that for hip arthroplasty patients readmission surveillance until day 30 for an SSI is performed. Two patients (15.4%) with SSI were identified between 30 days post operative and 10 months and these infections would not have been detected through standard surveillance methods currently adopted. If the current programme of surveillance was to include readmission until day 30 for hip and knee arthroplasty procedures then 69.2% of all SSIs identified in this study would have been captured.

9 Limitations

This study was carried out on a patient population from a single hospital and only for elective hip and knee arthroplasty patients therefore the methodology requires replication in differing settings and surgical patient populations to ensure the transferability of the findings. Direct observation of wounds was carried out for all SSI and this may not be achievable within other settings due to the staff and time resources required and the cost implications associated.

10 Implications for practice and further research

This study should be replicated in other surgical groups to test its feasibility as a method for data collection of post discharge SSI. Whilst this study explored the economic feasibility of this method for PDS, to the knowledge of the authors of this study no research has been conducted to examine the societal impact of SSI for patients or to assess the impact SSI has on patient's who have undergone orthopaedic surgery and subsequently developed infection.

11 Summary

Post discharge surveillance of SSI is necessary if accurate rates of HAI following surgery are to be reported. PDS using telephone interviews to identify patients who think they have an infection, or who are unsure whether they have an infection, and are followed up by a healthcare worker trained to diagnose infection according to agreed criteria is an effective method of identifying post discharge SSI. Although the accuracy of reported SSI rates are increased with the addition of PDS, methods utilised for this study were resource intensive, and it is therefore recommended the current programme of surveillance is expanded to include readmission surveillance until day 30 for knee arthroplasty procedures.

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13 Appendices

Appendix 1: Standard telephone interview schedule

Description	Options
Q1. Patient ID code	
Q2. Date of operation	
Q3. Laterality of procedure	left, right, not recorded
Q4. Date of review	
Q5. Review period	Day 15, day 30, month 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Q6. Was the patient inpatient at review period?	no, yes- patient has not yet been discharged after arthroplasty surgery, yes- for reason other than original surgery
Q7 Is the patient inpatient in a hospital within the study boundary?	yes, no
Q8. Do you think you have developed a wound infection?	yes, no, not sure
Q9. Is the area around the wound red and inflamed?	yes, no, not sure
Q10. Is the area around the wound swollen?	yes, no, not sure
Q11. Is the wound painful?	yes, no, not sure
Q12. Is the wound hot to touch?	yes, no, not sure
Q13. Do you have any fluid leaking from your wound?	yes, no, not sure
Q14. If Yes, is the fluid clear?	Yes
Q15. If Yes, is the fluid pus/cloudy yellow?	Yes
Q16. If Yes, is the fluid pink, red or blood?	Yes
Q17. Is the wound gaping open?	yes, no, not sure
Q18. Do you have a temperature?	yes, no, not sure
Q19. If recorded was it 38°C or more?	yes, no, not sure
Q20. Since discharge/last review, has the district nurse or GP seen the wound?	yes, no, not sure
Q21. Date district nurse or GP saw wound	
Q22. Since discharge/last review, has a hospital doctor/nurse seen the wound?	yes, no, not sure

Q23. Date hospital doctor/nurse saw wound

Q24. If seen in hospital, was the wound reopened?
yes, no

Q25. What date was the wound reopened

Q26. Since discharge/last review, has a wound specimen been taken?
yes, no, not sure

Q27. If applicable, how many days after your operation did you first notice any sign of infection?

Q28. Have you been prescribed antibiotics for a wound infection since discharge/last review?
yes, no, not sure

Q29. Date of first attempt at contact

Q30. Time of first attempt of contact (hours)
Time of first attempt of contact (mins)

Q31. Length of time on 1st call (mins)

Q32. Date of 2nd attempt at contact

Q33. Time of 2nd attempt of contact (hours)
Time of 2nd attempt of contact (mins)

Q34. Length of time on 2nd call (mins)

Q35. Date of 3rd attempt at contact

Q36. Time of 3rd attempt of contact (hours)
Time of 3rd attempt of contact (mins)

Q37. Length of time on 3rd call (mins)

Q38. Date of 4th attempt at contact

Q39. Time of 4th attempt of contact (hours)
Time of 4th attempt of contact (mins)

Q40. Length of time on 4th call (mins)

Q41. Was surveillance ended at this review period?
yes, no

Q42. Why was surveillance ended at this review period?
death, patient meets exclusion criteria,
loss to follow up, end of 12month follow up

Q43. Additional notes/comments

Appendix 2: CDC Definitions for SSI[3]

Definition For surveillance classification purposes, SSI is divided into incisional SSI and organ/space SSI. Incisional SSIs are further classified into those involving only the skin and subcutaneous tissue (called superficial incisional SSI) and those involving deep soft tissues of the incision (called deep incisional SSI e.g., fascial and muscle layers). Organ/space SSI involve any part of the anatomy (e.g. organs or spaces), other than the incision, opened or manipulated during the operative procedure.

Superficial SSI (Incisional)

A superficial SSI must meet the following criterion:

1. Infection occurs within 30 days after the operative procedure
2. And involves only skin and subcutaneous tissue of the incision
3. And patient has at least one of the following:

- Purulent discharge from the superficial incision
- Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision (fluid or tissue sample)
- At least one of the following signs or symptoms of infection: pain or tenderness, localised swelling, redness, or heat and superficial incision is deliberately opened by surgeon unless incision is culture negative
- Diagnosis of superficial incisional SSI by a surgeon or trained healthcare worker*

The following are not reported as superficial incisional SSI:

- Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration)
- Infected burn wound
- Incisional SSI that extends into the fascial and muscle layers (deep incisional SSI)

Classify infection that involves both superficial and deep incision sites as deep incisional SSI.

*Trained healthcare worker is defined as a qualified nurse or doctor who has been trained in the national definitions for SSI

Deep SSI (Incisional)

A deep incisional SSI must meet the following criterion:

1. Infection occurs within 30 days after the operative procedure if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operative procedure

2. And involves deep soft tissues (e.g. fascial and muscle layers) of the incision
3. And patient has at least one of the following:

- Purulent discharge from the deep incision but not from the organ/space component of a surgical site
- A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C) or localised pain or tenderness, unless incision is culture negative
- An abscess or other evidence of infection involving the deep incision is found on direct examination, during re operation, or by histopathological or radiological examination
- Diagnosis of a deep incisional SSI by a surgeon or trained healthcare worker

Organ/Space SSI

An organ/space SSI involves any part of the body, excluding the skin incision, fascia, or muscle layers that is opened or manipulated during the operative procedure. Specific sites are assigned to organ/space SSI to further identify the location of the infection. An example is an appendicectomy with subsequent diaphragmatic abscess, which would be reported as an organ/ space SSI at the intra-abdominal specific site.

An organ/space SSI must meet the following criterion:

1. Infection occurs within 30 days after the operative procedure if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operative procedure
2. And infection involves any part of the body, excluding the skin incision, fascia, or muscle layers that is opened or manipulated during the operative procedure.
3. And at least one of the following:

- Purulent discharge from a drain that is placed through a stab wound into the organ/space
- Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space
- An abscess or other evidence of infection involving the organ/space that is found on direct examination, during re operation, or by histopathological or radiological examination
- Diagnosis of an organ/space SSI by a surgeon or trained healthcare worker

Occasionally an organ/space infection drains through the incision. Such an infection generally does not involve re operation and is considered a complication of the incision. Therefore, it is classified as a deep incisional SSI.

Appendix 3: Validation Form

Description	Options
Q1. Patient ID code	
Q2. Date of operation	
Q3. Laterality of procedure	left, right, not recorded
Q4. Review period	Day 15, day 30, month 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Q5. Date you saw the patient?	
Q6. Do you think the wound is infected?	yes, no
Q7. Which type of SSI is it?	superficial, deep, organ/space
Q8. Purulent drainage	yes
Q9. Localised swelling	yes
Q10. Redness	yes
Q11. Heat	yes
Q12. Incision spontaneously dehisced	yes
Q13. Localised pain or tenderness	yes
Q14. Incision was deliberately reopened	yes
Q15. Fever (temperature 38°C or more)	yes
Q16. Limitation of motion in the joint	yes
Q17. Evidence of effusion	yes
Q18. Abscess found on examination or radiology or histopathology	yes
Q19. Has a wound specimen been taken?	yes- fluid, Yes- tissue, Yes- swab, No
Q20. Have any radiology tests been requested to diagnose SSI?	yes, no, not sure
Q21. Have any blood tests been requested to diagnose SSI?	yes, no, not sure
Q22. Have any urine tests been requested to diagnose SSI?	yes, no, not sure
Q23. Have any joint fluid tests been requested to diagnose SSI?	yes, no, not sure
Q24. Has a bone biopsy been requested to diagnose SSI?	yes, no, not sure

Burden Questions

Q25. Have antibiotics been prescribed for the wound infection?

yes, no, not sure

Q26. Please indicate type of antibiotic prescribed

Q27. How many courses have been prescribed for this wound infection?

Q28. Have you attended/been visited by a district nurse in relation to your infected wound?

yes, no, not sure

Q29. If YES, how many times have you seen the district nurse?

Q30. Have you attended/been visited by a GP in relation to your infected wound?

yes, no, not sure

Q31. If YES, how many times have you seen the GP?

Q32. Was the patient readmitted due to the SSI?

yes, no

Q33. What date was the patient readmitted?

Q34. What date was the patient discharged after readmission?

Q35. Did the patient require reoperation during readmission due to SSI?

yes, no

Appendix 4: NNIS Risk Score

The NNIS Risk Score is calculated using three major risk factors:

1) ASA Score

An assessment by the anaesthetist of the patient's preoperative physical condition using the American Society of Anesthesiologists (ASA) classification of physical status.

Provides data to calculate infection rates by ASA classification and is an element of the NNIS SSI risk index.

1. Normal healthy patient
2. Patient with mild systemic disease
3. Patient with severe systemic disease that is not incapacitating
4. Patient with an incapacitating systemic disease that is a constant threat to life
5. Moribund patient who is not expected to survive for 24 hours with or without operation.

2) Wound class

Wound class is the likelihood of micro organisms being present in the wound at the time of surgery:

Clean Wounds:

The wound is judged to be clean when the operative procedure does not enter into a normally colonised viscus or lumen of the body.

Clean-Contaminated Wounds:

A clean-contaminated surgical site is seen when the operative procedure enters into a colonised viscus or cavity of the body, but under elective and controlled circumstances.

Contaminated Wounds:

Contaminated procedures occur when gross contamination is present at the surgical site in the absence of obvious infection.

Dirty Wounds:

Surgical procedures performed when active infection is already present are considered dirty wounds.

3) Duration of surgical procedure

Operative Procedure Category	**T Point**
Hip arthroplasty	2 hrs
Knee arthroplasty	2 hrs

This risk index has a range from 0 to 3 points. A point is added to the patient's risk index for each of the following 3 variables:

- 1 point - the patient has an ASA preoperative assessment score of 3, 4, or 5
- 1 point - the patient has an operation that is classified as either contaminated or dirty
- 1 point - the duration of the operation exceeds the 75th percentile where a standard T point (75% percentile) was determined from the NNIS database; the T point is defined as the length of time in hours that represents the 75th percentile of procedures reported in the NNIS survey

Patients with a score of 0 are at the lowest risk of developing an SSI while those with a score of 3 have the greatest risk.