How will surgical site infection be measured to ensure “high quality care for all”?

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As of April 2010 all NHS institutions in the United Kingdom are required to publish data on surgical site infection, but the method for collecting this has not been decided. We examined 7448 trauma and orthopaedic surgical wounds made in patients staying for at least two nights between 2000 and 2008 at our institution and calculated the rate of surgical site infection using three definitions: the US Centers for Disease Control, the United Kingdom Nosocomial Infection National Surveillance Scheme and the ASEPSIS system. On the same series of wounds, the infection rate with outpatient follow-up according to Centre for Disease Control was 15.45%, according to the UK Nosocomial infection surveillance was 11.32%, and according to ASEPSIS was 8.79%. These figures highlight the necessity for all institutions to use the same method for diagnosing surgical site infection.

If different methods are used, direct comparisons will be invalid and published rates of infection will be misleading.

In June 2008 the Department of Health in the United Kingdom published a report entitled “*High Quality Care For All*”.¹ This stated that by April 2010, healthcare providers working for or on behalf of the NHS must publish ‘quality accounts’. These will cover three aspects of patient care: safety, patient experience and patient outcome. As part of the safety aspect, rates of surgical site infection (SSI) will be published.

SSI is a major risk in all orthopaedic surgery. It causes pain and can lead to wound dehiscence, deep infection and generalised sepsis. Further surgery and admission to intensive care may be necessary. A patient with an SSI spends twice as long in hospital.² It is therefore not only distressing for the patient but also an economic burden.

In the report “*High Quality Care For All*” report, seven steps were described to improve quality. These are to set standards of high quality; measure quality; publish quality performance; recognise and reward quality; raise standards; safeguard quality; and stay ahead by encouraging innovation. The report stated that data on SSI will soon be available on the NHS Choices website (step 3) but did not state what a ‘good’ rate of SSI is (step 1), nor did it describe how such rates will be measured (step 2). This paper concentrates on step 2 and examines the methods commonly used to measure SSI.

There is a misconception that SSIs are easy to define and diagnose. There are several definitions of SSI and the diagnosis of infection varies between surgeons. They were traditionally diagnosed using the findings on examination of pain, redness, heat, swelling and impairment of function. As surgeons became increasingly accountable for their practice, more reliable and reproducible methods of diagnosing SSI became necessary. There are three definitions in use today (i) the US Centers for Disease Control (CDC), (ii) the English Nosocomial Infection National Surveillance Scheme (NINSS) and (iii) an English system which combines scores for additional treatment, serous discharge, erythema, purulent exudate, separation of deep tissues, isolation of bacteria and stay as an in-patient (ASEPSIS).

The CDC definition³ is used throughout the world and divides SSIs into incisional and organ/space infections. Incisional SSIs are further divided into superficial and deep infections (Table I). Several of the CDC criteria are subjective, and on psychometric evaluation have been shown to be unreliable.⁴

The United Kingdom NINSS definition of SSI is based on the CDC, with two significant modifications. Firstly, pus cells must be present for a wound culture to be classified as positive and secondly, a surgeon’s diagnosis of infection is excluded as a sufficient criterion to diagnose SSI. These changes were implemented to

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Table I. The Center for Disease Control definition of surgical site infection

	Superficial infection (involving skin and superficial tissues)	Deep infection (involving the fascial and muscle layers)
Time period	Occurs within 30 days of surgery	Occurs within 30 days of surgery or within one year if implant present
Site	Involves only the skin and superficial tissue	Related to the surgical site and involves deep tissues
Further criteria	Must fulfil one of the following: Purulent discharge from superficial incision Organisms isolated from incision. Pain, tenderness, swelling, redness or heat around the incision AND the incision deliberately opened by a surgeon (unless cultures are negative) Diagnosis by a surgeon or physician	Must fulfil one of the following: Purulent discharge from deep incision Spontaneous dehiscence or deliberate opening of a deep incision, following fever or pain or tenderness around the wound (unless cultures are negative) Abscess involving a deep incision Diagnosis by a surgeon or physician

Table II. Points scale used to calculate total ASEPSIS score

Criterion	Points
Additional treatment	
Antibiotics	10
Drainage of pus under local anaesthetic	5
Debridement of wound under general anaesthetic	10
Serous discharge	0 to 5
Erythema	0 to 5
Purulent exudate	0 to 10
Separation of deep tissues	0 to 10
Isolation of bacteria	10
Stay in hospital over 14 days	5

Table III. Points scale for ASEPSIS daily wound inspection

	Proportion of wound affected (%)					
	0	> 0 to 19	20 to 39	40 to 59	60 to 79	80 to 100
Serous exudate	0	1	2	3	4	5
Erythema	0	1	2	3	4	5
Purulent exudates	0	2	4	6	8	10
Separation of deep tissues	0	2	4	6	8	10

Table IV. Breakdown of ASEPSIS scores

Score	Meaning
0 to 10	No infection Normal healing
11 to 20	Disturbance of healing
21 to 30	Minor infection
31 to 40	Moderate infection
≥ 41	Severe infection

Table V. Patient demographics

Gender	
M:F	44:56
Mean age in years (range)	56.4 (0 to 99)
ASA* ¹⁴ (%)	
I	2109 (28.3)
II	3639 (48.9)
III	1595 (21.4)
IV	105 (1.4)
Type of surgery	
Elective: emergency	86:14

* ASA, american society of anesthesiologists

improve the objectivity of CDC, but the reproducibility of NINSS remains low.⁵

ASEPSIS is a quantitative wound scoring method.⁶ The score is calculated using objective criteria based both on visual characteristics of the wound and the consequences of infection (Tables II and III). A score of > 10 indicates an increasing probability and severity of infection (Table IV). The original ASEPSIS method has been shown to be both objective and repeatable,⁷ but a more recent revised version has not been psychometrically evaluated.

Scoring methods provide more detailed information than the CDC and NINSS but are more complicated to perform, more time-consuming and more costly. It takes an average of 59 minutes to collect the data and calculate an ASEPSIS score.⁸

Table VI. Infection rates according to CDC, NINSS and ASEPSIS

Definition*	Number of uninfected wounds (%)	Number of infected wounds (%)	95% CI† for infection rate
CDC	6297 (84.55)	1151 (15.45)	14.63 to 16.27
NINSS	6605 (88.68)	843 (11.32)	10.60 to 12.04
ASEPSIS	6793 (91.21)	655 (8.79)	8.15 to 9.44

* CDC, center for disease control; NINSS, nosocomial infection national surveillance scheme

† CI, confidence interval

The purpose of this prospective observational study was to assess the rate of SSI in orthopaedics according to these three common definitions.

Patients and Methods

In May 2000 a wound surveillance programme began in the Department of Trauma and Orthopaedics at University College Hospital, London. For the first two years, because of funding restraints, data were collected for six months of each year, from May to October. This represented 35% of total orthopaedic admissions. From 2002 onwards, collection of data became continuous. This study is part of a hospital audit programme and so formal ethical approval was not required.

All trauma and elective orthopaedic patients with a minimum of two-nights stay in hospital and an operation involving the incision of tissue were included in the programme. Traumatic wounds were not included, only incisions made at the time of surgery.

Wounds were assessed by a member of a specialist team, made up of four nurses and a healthcare assistant. The sole role of this team was to collect and record data on wound infection, and all members received specialist training in the different definitions and diagnosis of surgical site infection.

Each patient was reviewed on three separate occasions, once pre-operatively and twice post-operatively. The same standardised data collection sheet was completed for each patient. The information collected pre-operatively included patient demographics and the name of the consultant in charge. Operative information and microbiology results came from a direct interface with other hospital computer databases. Microbiology tests, such as wound swabs or tissue cultures, were performed according to clinical judgement. No specific microbiology tests were requested for study purposes alone.

Surgical wounds were inspected two or three days after operation and again on days four or five if the patient remained in hospital. The proportion of each wound exhibiting erythema, serous discharge, purulent discharge or dehiscence was recorded. Wounds were inspected directly if visible, but if a dressing was present the relevant information was gained by questioning nursing staff. This was done to avoid an unnecessary increase in the risk of infection. The nurses were encouraged to fill in the data collection sheet at the time of dressing change.

Fig. 1

Graph showing infection rates (CDC, center for disease control; NINSS, nosocomial infection national surveillance scheme).

At each post-operative visit the notes and drug charts of the patient were inspected. The diagnosis of a wound infection by a medical practitioner, the prescription of prophylactic or therapeutic antibiotics and the opening of a wound or drainage of an abscess were recorded.

At the time of discharge patients were given a simple 'yes/no' questionnaire regarding their wound, which they were asked to complete and return in a pre-paid envelope two months later. They were contacted by telephone if no postal questionnaire was returned. The questionnaire was used to ascertain whether a wound infection had been diagnosed since discharge, whether antibiotics had been prescribed for the wound, whether any further surgery had been necessary and whether the hospital stay had been longer than 14 days.

The data were stored on a modified Access 97 database which was only accessible to members of the surveillance team. A single patient episode was defined as an operation with follow-up of either three months or until a further operation was performed, whichever was shorter. At any time point, SSI resulting in readmission was recorded in the database. Sufficient information was gathered to allow each wound to be diagnosed according to the CDC, NINSS and ASEPSIS definitions.

Table VII. 'Superficial' and 'deep' incisional infection rates according to CDC and NINSS

Definition*	Number of wounds with no infection (%)	Number of wounds with superficial incisional infection (%)	Number of wounds with deep incisional infection (%)
CDC	6297 (84.5)	689 (9.3)	462 (6.2)
NINSS	6605 (88.7)	663 (8.9)	180 (2.4)

* CDC, center for disease control; NINSS, nosocomial infection national surveillance scheme

Table VIII. Grade of infection according to ASEPSIS

Grade of infection	Number of wounds (%)
No infection	6110 (82.0)
Disturbance in healing	683 (9.2)
Infection	
Minor	297 (4.0)
Moderate	140 (1.9)
Severe	218 (2.9)

Table IX. Agreement between CDC* and ASEPSIS infection rates

	CDC		Total (%)
	No infection (%)	Infection (%)	
ASEPSIS			
No infection	6133 (82.3)	660 (8.9)	6793 (91.2)
Infection	164 (2.2)	491 (6.6)	655 (8.8)
Total	6297 (84.5)	1151 (15.5)	7448 (100.0)

* CDC, center for disease control

Table X. Agreement between NINSS* and ASEPSIS infection rates

	NINSS		Total (%)
	No infection (%)	Infection (%)	
ASEPSIS			
No infection	6312 (84.7)	481 (6.5)	6793 (91.2)
Infection	293 (3.9)	362 (4.9)	655 (8.8)
Total	6605 (88.6)	843 (11.4)	7448 (100.0)

* NINSS, nosocomial infection national surveillance scheme

Table XI. Agreement between NINSS* and CDC† infection rates

	NINSS		Total (%)
	No infection (%)	Infection (%)	
CDC			
No infection	6275 (84.2)	22 (0.3)	6297 (84.5)
Infection	330 (4.5)	821 (11.0)	1151 (15.5)
Total	6605 (88.7)	843 (11.3)	7448 (100.0)

* NINSS, nosocomial infection national surveillance scheme

† CDC, center for disease control

Statistical analysis. Crude infection rates were calculated for each definition of infection and 95% confidence intervals calculated. The agreement between crude infection rates was calculated using the κ statistic. Kendall's tau b value was used to assess correlation between the subdivisions of each definition.

Results

Between May 2000 and October 2008, 7448 orthopaedic wounds were assessed in 7299 patients. The patient demographics are shown in Table V. The rate of follow-up of patients two months after surgery was 91%.

The crude infection rates according to CDC, NINSS and ASEPSIS are shown in Table VI and the incidence of infection according to the three definitions over time is shown in Figure 1. CDC and NINSS can be divided into 'no infection', 'superficial incisional infection' and 'deep incisional infection' (Table VII). ASEPSIS can be divided into 'no infection', 'disturbance of healing', 'mild infection', 'moderate infection' and 'severe infection' (Table VIII).

Tables IX, X and XI show the level of agreement of crude infection rates for the three definitions. The agreement between CDC and ASEPSIS is 88.94% (κ statistic 0.4861, $p < 0.0001$), that between NINSS and ASEPSIS is 89.61% (κ

statistic 0.4266, $p < 0.0001$) and that between CDC and NINSS is 95.27% (κ statistic 0.7969, $p < 0.0001$).

Tables XII, XIII and XIV show the level of agreement between the subgroups of the three definitions of SSI. Kendall's tau b correlation coefficient between ASEPSIS and CDC is 0.5932, between ASEPSIS and NINSS is 0.4493, and between NINSS and CDC is 0.7870 (all $p < 0.0001$).

Discussion

Wound surveillance in the same series of patients gives varying rates of SSI depending on the definition used. On this series of 7448 patients, the SSI rate according to the CDC was 15.45%, according to the NINSS was 11.32% and according to ASEPSIS was 8.79%. The latter has previously been compared with other definitions of SSI,⁹ but never in a series of trauma and orthopaedic patients only.

Further breakdown of ASEPSIS scores reveals that 9.17% of patients had disturbance of healing (score 11 to 20). A score of 11 to 20 is known to include some infected wounds, but in most cases is thought to indicate wound breakdown from another cause.¹⁰ If these patients were regarded as having 'true' infections, the SSI rate according to ASEPSIS would be similar to the rate according to CDC and NINSS.

Table XII. Agreement between CDC* superficial and deep incisional infection rates and ASEPSIS scores

	CDC definition			Total
	No infection (%)	Superficial infection (%)	Deep infection (%)	
ASEPSIS score				
0 to 10	5770 (77.5)	304 (4.1)	36 (0.5)	6110 (82.1)
11 to 20	363 (4.9)	226 (3.0)	94 (1.3)	683 (9.2)
21 to 30	89 (1.2)	98 (1.3)	110 (1.5)	297 (4.0)
31 to 40	18 (0.2)	50 (0.7)	72 (1.0)	140 (1.9)
> 40	57 (0.8)	11 (0.1)	150 (2.0)	218 (2.9)
Total	6297 (84.6)	689 (9.2)	462 (6.2)	7448 (100.0)

* CDC, center for disease control

Table XIII. Agreement between NINSS* superficial and deep incisional infection rates and ASEPSIS scores

	NINSS definition			Total
	No infection (%)	Superficial infection (%)	Deep infection (%)	
ASEPSIS score				
0 to 10	5814 (78.1)	281 (3.8)	15 (0.2)	6110 (82.0)
11 to 20	498 (6.7)	166 (2.2)	19 (0.3)	683 (9.2)
21 to 30	172 (2.3)	101 (1.4)	24 (0.3)	297 (4.0)
31 to 40	33 (0.4)	86 (1.1)	21 (0.3)	140 (1.9)
> 40	88 (1.2)	29 (0.4)	101 (1.4)	218 (2.9)
Total	6605 (88.7)	663 (8.9)	180 (2.4)	7448 (100.0)

* NINSS, nosocomial infection national surveillance scheme

Table XIV. Agreement between NINSS* and Center for Disease Control (CDC) superficial and deep incisional infection rates

	NINSS definition			Total
	No infection (%)	Superficial infection (%)	Deep infection (%)	
CDC classification				
No infection	6275 (84.3)	22 (0.3)	0 (0.0)	6297 (84.6)
Superficial infection	121 (1.6)	568 (7.6)	0 (0.0)	689 (9.2)
Deep infection	209 (2.8)	73 (1.0)	180 (2.4)	462 (6.2)
Total	6605 (88.7)	663 (8.9)	180 (2.4)	7448 (100.0)

* NINSS, nosocomial infection national surveillance scheme

A positive correlation was found between an increasing ASEPSIS score and deep incisional infection according to the CDC and the NINSS. Therefore, the higher the ASEPSIS score, the greater the likelihood of a deep incisional SSI.

The strengths of this study are that it is prospective, there is a large study population and a dedicated wound surveillance team with specialist training who collected and recorded the data. One weakness is that some of the data was recorded by ward nurses, leading to a possible decrease in inter-observer reliability. In order to minimise this problem, each nurse completed a standardised simple results table with tick-boxes, and all wound observations were verified by the surveillance team asking the ward nurses specific questions.

Wound surveillance in orthopaedic surgery became mandatory in the NHS in England in 2004. Reported rates of SSI depend on the method used for diagnosis, the case mix, the thoroughness of surveillance and documentation, and the duration of patient follow-up. Follow-up after discharge is essential in any wound surveillance programme, as more than half of SSIs present after discharge.¹¹

Wound surveillance has several advantages. Firstly, the feedback of rates of infection to surgeons has been shown to reduce them.¹⁰ Secondly, outliers can be identified so that good practice can be recognised and propagated, and poor practice can be highlighted and improved. Thirdly, rates of SSI can be used as a performance indicator to compare surgeons, departments, hospitals and countries. However, a

dedicated programme with full outpatient follow-up can result in apparently high rates of infection being reported. Comparison should only be made within the institution or with hospitals operating to the same standards.

This study illustrates the need for a single accurate and reproducible definition of SSI to allow its use as a reliable performance indicator. The three definitions investigated here are not directly comparable, and at present there is no good evidence as to which is best to use. The CDC is used worldwide, but this popularity may be unwarranted as the definition is subjective and has been shown to be unreliable.⁴ The United Kingdom NINSS version of CDC was devised in an attempt to make CDC more objective, but again NINSS is not reproducible.⁴ The difference in reported infection rates according to CDC and NINSS in this study shows how a small alteration in the definition of the former has a marked effect on the reported outcome. Methods of wound scoring are claimed to be superior to those of the CDC and NINSS, because they provide more information and are objective.

From 2010, hospitals will no longer be paid a fixed tariff for each procedure: instead, they will receive a variable amount according to 'outcome'. Therefore, hospitals with lower SSI rates will receive higher tariffs. In order for this to be fair, the rates must be reported in a reliable and accurate fashion.

We recommend the use of the ASEPSIS scoring method. Both CDC⁴ and NINSS⁵ have been shown to be unreliable. The original ASEPSIS method is objective and repeatable,⁷ but a more recent revised version has not been psychometrically evaluated and this must be promptly addressed.

Before the publication of SSI rates within the profession and to the general public, the Department of Health must clearly define it. If different diagnostic methods are used by different institutions, any comparison will be meaningless and misleading.

Supplementary material

A further opinion by Professor S. Hughes is available with the online version of this article on our website at www.jbjs.org.uk

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