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Automating the monitoring of surgical site infections using variable life-adjusted display charts

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SUMMARY

We describe a software tool specifically developed to support the monitoring and reporting of the occurrence of surgical site infections (SSI) in hospitals. The tool uses data collected routinely by a London teaching hospital as part of its infection surveillance system, which includes post-discharge follow-up. Based on these data, the tool is used to generate graphs showing cumulative infections over time and variable life-adjusted display (VLAD) charts that account for the expected specialty average infection risk. The user can select, along with other options, the definition of infection used in the preparation of the graphs. Using an illustrative example of SSI monitoring in orthopaedic surgery, we demonstrate the tool and its intended use to trigger further scrutiny rather than draw firm conclusions. We show that the tool has the ability to generate departmental debate, which should ultimately lead to the increased safety of surgical patients. We recommend adopting the tool and VLAD charts wherever surgical site surveillance is continuous.

Introduction

Surgical site infections (SSIs) are one of the most common hospital-acquired infections and represent a substantial cause of morbidity and mortality.[1,2] Monitoring and providing feedback of SSI rates has been found to be effective in reducing infections over a five-year period.[3,4] Recently developed advanced infection-monitoring approaches employ the variable life-adjusted display (VLAD) technique for graphical presentation of a series of clinical outcomes.[5] The VLAD was originally developed for the monitoring of clinical outcomes such as perioperative mortality in cardiac surgery but its use has spread beyond a single specialty or outcome measure.[6–8] Among the advantages of the VLAD approach are that it is easy to use and interpret by clinical staff and that variations in case-mix can be readily taken into account.[9]

The participating hospital has had a surveillance system that includes post-discharge follow-up and feedback of SSI data to surgeons since May 2000. Data are collected both before and after hospital discharge by an independent dedicated team and entered into a specially designed database. Collated results are sent to individual surgeons, the hospital administration and the surgical directorate quarterly. Overall, the surveillance system has been shown to reduce infection rates in a cost-effective manner.[3] However, the lack of an automated tool has been the main obstacle in including VLAD charts routinely in the monitoring process as the *ad hoc* production of such charts by general-purpose software available online is time consuming, cumbersome and requires specialist technical knowledge to transfer data between different software environments.

We developed such a software tool (Surgical Wound Infection Monitoring – SWIM) as part of an action research programme between the collaborating hospital and academic unit and included a version of VLAD charts in the routine monitoring and reporting of the occurrence of SSI based on the readily available data in the hospital's database. Here we present the software tool, its user interface and the type of charts it generates. We demonstrate the use of this tool for the continuous monitoring of SSI and discuss some of the benefits and limitations of the approach.

Methods

The SSI surveillance database of the hospital contains more than 35,000 records of patients undergoing an operation involving incision of tissue with a postoperative hospital stay of at least two

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days, excluding day surgery and endoscopy. All surgical specialties are included for six consecutive months per year, with the exception of cardiac and orthopaedic surgery for which, since November 2002, data have been recorded continuously throughout the year.

Patients are usually visited by dedicated surveillance staff twice after the operation, on day 2 or 3 and day 4 or 5. Information on patients is imported electronically from other hospital information systems collecting patient admission and operation data. Post-discharge data are gathered either by telephone or postal questionnaire between 30 and 60 days after the operation. Overall, the surveillance database includes details of patient demographics, height, weight, consultant surgeon, operation type, duration, degree of contamination, dressing, prophylactic and therapeutic antibiotics, body temperature, American Society of Anesthesiologists (ASA) score, and proportion of surgical sites affected by erythema, serous or purulent exudates and dehiscence. Further information about the data collected within the surveillance database and the postal questionnaire is described elsewhere.[3]

These data allow the presence of SSI to be determined by means of a custom computer algorithm and according to a number of definitions and scoring methods. The definitions employed include the US Centers for Disease Control (CDC), the UK modification used by the Surgical Site Infection Surveillance Service (SSISS), and the UK National Prevalence Survey (NPS); ASEPSIS, also included in the database, is a scoring method which includes criteria that add points for prolonged stay or readmission as a result of infection.[10–13] According to the method, wounds can be categorised by the total score as: 0–10, normal; 11–20, disturbance of healing; 21–30, minor infection; 31–40, moderate infection; >40, severe infection. In general, a score of >10 points indicates an increased probability and severity of SSI. Depending on the purposes of monitoring, different threshold values are chosen over which a wound is deemed infected.

In the tool we used a modified version of the VLAD chart, which displays the difference between the cumulative number of observed infections and the number of expected infections over a series of patients or over time. Whenever the plot of a surgeon or a surgical unit has the value zero, then observed and expected numbers of infections are equal; when the plot rises above the horizontal axis (>0) it means that the number of observed infections is greater than expected; when it falls below the axis (<0) then the observed number of infections is less than expected. Upward or downward trends point to runs (either in terms of consecutive cases or consecutive days) of worse or better than expected infection outcomes respectively. Note that a VLAD chart usually displays the reverse: the cumulative number of expected outcomes minus the number of observed outcomes.[6] We chose to plot the inverted VLAD measure to ensure compatibility with the unadjusted cumulative infection chart in which infections are also shown by upward trends.

The number of expected infections is calculated by summing the estimated probabilities of infection associated with each individual patient included in the chart. In this tool we chose to assign each patient under a given specialty the same average infection

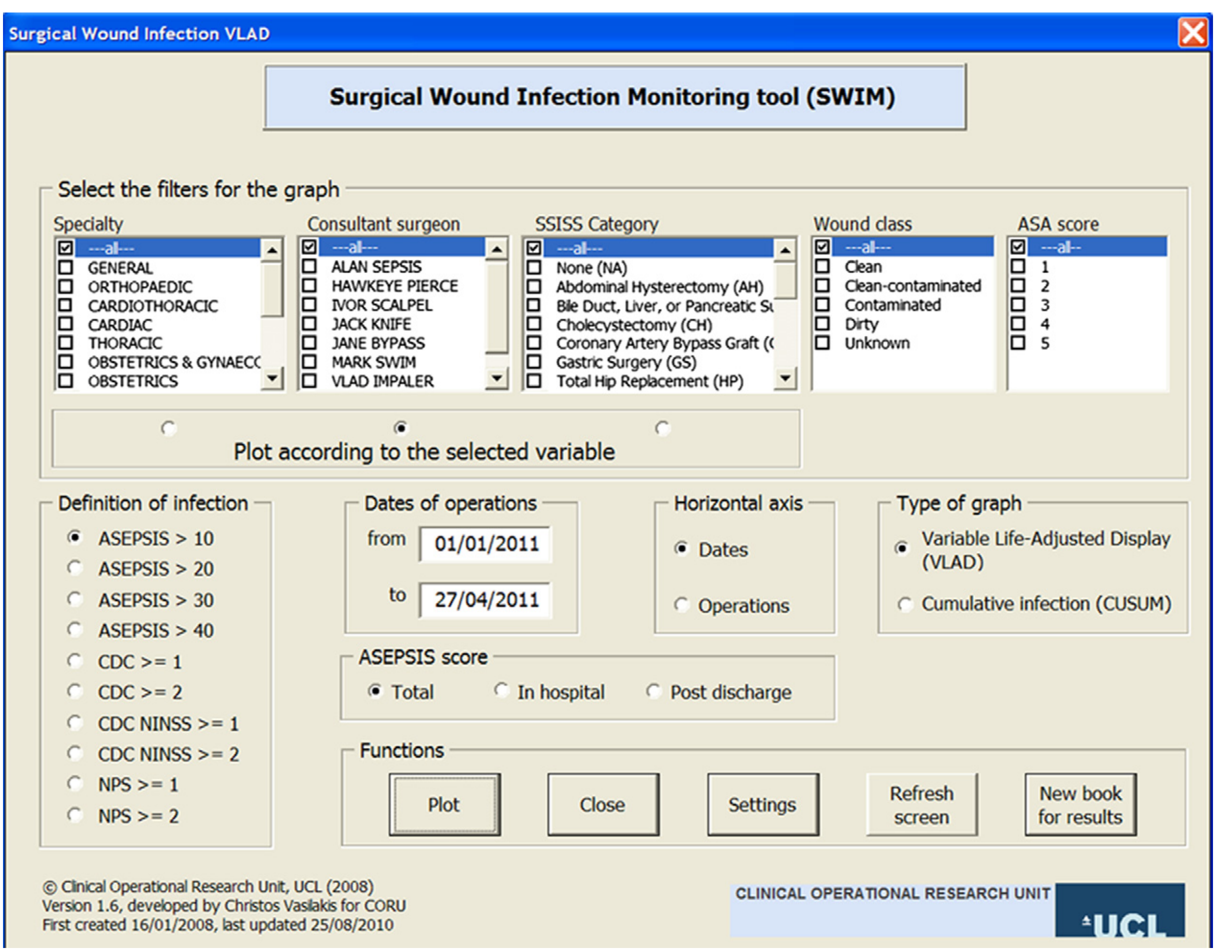

Figure 1. Screenshot of main interface form of the software tool (the list of names of consultant surgeons is fictitious).