Prevalence of healthcare device-associated infection using point prevalence surveys of antimicrobial prescribing and existing electronic data

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S U M M A R Y

This study extended a previously described method for the prevalence of healthcare-associated infection, based on point prevalence surveys of antimicrobial prescribing and electronic data, to estimate the prevalence of device-associated infections. In June 2009, the six-month point prevalence survey of antimicrobial prescribing was carried out in accordance with the European Surveillance of Antimicrobial Consumption Protocol. For patients receiving antimicrobials the presence of devices was recorded. A census on device use was carried out concurrently in the relevant hospitals. We selected patients receiving antimicrobials, started >48 h after admission and who had a device, or who were without a device but were receiving antimicrobials for the treatment of bloodstream infection, urinary tract infection, or pneumonia. From existing positive microbiological and radiology reports, these patients were assessed for the presence of device-associated infection according to specified definitions. Of 1354 patients surveyed, 253 (19%) were receiving antimicrobials for treatment; of these, 189 also had devices and 172 (only 13% of all patients surveyed) needed individual assessment for the presence of device-associated infection. It took about 5 min per patient to check electronic microbiology and/or radiology reports. Twenty-three patients met the criteria for device-associated infection. The prevalence of catheter-associated urinary tract infection, central-line-associated bloodstream infection, local vascular access infection, and ventilator-associated pneumonia was 3.9%, 3.1%, 3.8% and 11.6%, respectively. This is a simple method, which can be adopted in other hospitals, to estimate the prevalence of device-associated infection using pre-existing data.

Introduction

In England, the surveillance of healthcare-associated infection (HAI) is targeted at meticillin-resistant Staphylococcus aureus (MRSA) bloodstream infection (BSI), Clostridium difficile, and surgical site infection (SSI). However, national data on other preventable HAIs, such as device-associated infections, is limited. In 2009, the National Audit Office recommended that a mandatory surveillance system for other infections such as non-MRSA BSIs and device-associated infections should be developed.1

Traditional hospital-wide surveillance systems are time consuming, and labour intensive. They use manual data collection and US Centers for Disease Control and Prevention (CDC) definitions of HAI, which are prone to subjective judgements and which limit their utility for comparative purposes.2-4 A validation study of the CDC methodology to identify HAI showed a sensitivity of 59–85% and specificity of 72–87%.5

Prevalence surveys have been advocated as a relatively quick and inexpensive means of estimating the overall burden of HAI. However, UK national prevalence surveys are infrequent, labour intensive, and seem unlikely to provide timely information to improve local practice.6,7 By contrast, point prevalence surveys of antimicrobial prescribing are quicker and can be performed frequently.6,7

There is increasing recognition of the need for the development of automated systems for the surveillance of HAIs based on existing
electronic databases, such as patient information systems, microbiology laboratory results, antimicrobial administration and international classification of diseases diagnosis codes (ICD-9-CM or ICD-10). Automated methods have shown high sensitivity, specificity and positive predictive value when compared with traditional surveillance systems. Some argue that electronic algorithms combining the data from a variety of automated systems are more likely to be consistent over time and appropriate for benchmarking within and between hospitals.

At Imperial College Healthcare NHS Trust (ICHt) Brown et al. have developed a simple method to estimate the prevalence of HAI based on the Trust’s pharmacy serial point prevalence surveys of antimicrobial prescribing and positive electronic reports. When compared with the 2006 UK prevalence survey of HAI, this method had a sensitivity of 1.0 and specificity of 0.97 for non-surgical patients.

Device-associated infections are largely preventable and are a surveillance priority in national surveillance schemes such as the National Healthcare Safety Network at the CDC. In 2009, we extended and tested Brown’s methodology for the estimation of the prevalence of device-associated infections at ICHt and determined their contribution to the overall pool of HAI.

Methods

The Trust consists of five London teaching tertiary referral hospitals: Charing Cross, Hammersmith, St Mary’s, Queen Charlotte’s & Chelsea, and the Western Eye Hospital, and has about 200 000 admissions per year, including day cases.

The surveillance method is based on that previously developed by Brown et al. at ICHt to estimate the prevalence of HAI. The method uses data from prevalence surveys of antimicrobial prescribing as a marker for infection and existing positive electronic microbiology and radiology reports for confirmation of the infection. In June 2009, the Trust’s infectious disease pharmacists carried out their six-monthly point prevalence survey of antimicrobial prescribing in accordance with the standardised European Surveillance of Antimicrobial Consumption (ESAC) protocol (ESAC-3 2009 Protocol). In addition to antimicrobial data, the presence of intravascular devices, urinary catheters or ventilators for patients receiving antimicrobials was recorded. Concurrently with the pharmacy survey, the infection prevention and control team conducted a Trust-wide census to collect the total number of inpatients and the number with central and peripheral lines, urinary catheter, or a ventilator.

From the prevalence survey of antimicrobial prescribing we selected patients receiving antimicrobial therapy on the day of the survey, which started >48 h after admission, and who had an intravascular device, urinary catheter or ventilator in place, or who were without a central line, urinary catheter, or ventilator on the day of the survey, but were receiving antimicrobials for the treatment of BSI, urinary tract infection (UTI) or pneumonia, respectively.

These patients were investigated to determine whether they had positive microbiological and/or radiology reports within the two weeks previous to the day of the survey or, if the microbiological or the radiology test was done on the day of the survey, had positive reports in the week after the survey. Patients with positive reports were evaluated to determine whether these reports suggested a newly acquired infection that was not present within 48 h of admission and met any of the device-associated infections as defined below.

Catheter-associated UTI (CAUTI)

This was defined by a positive catheter specimen of urine (≥10⁵ micro-organisms/mL) with no more than two species of microorganism and where antimicrobials were prescribed for UTI. A positive microbiology result as defined above in patients who were not receiving antimicrobials for UTI was classified as asymptomatic catheter-associated bacteriuria.

Central line-associated BSI (CLABSI)

(a) One or more blood cultures positive for a recognised pathogen, or ≥2 blood cultures positive for a single species of a common skin commensal, and a positive catheter tip culture (≥15 cfu/mL) yielding the same organism as the blood culture within 48 h of the positive blood culture, and these organisms were not cultured from another site; or:

(b) Two blood cultures taken the same day from a venepuncture site and from a central line, both positive for the same recognised pathogen, or both positive for a single species of a common skin commensal organism in a patient for whom antimicrobials were being prescribed for BSI.

Local vascular access infection associated with a central line

A positive catheter tip culture (≥15 cfu/mL) from a central line in a patient with negative blood cultures who was receiving antimicrobials for local vascular access infection.

Ventilator-associated pneumonia (VAP)

Patient receiving antimicrobials for pneumonia and where a chest X-ray report indicated that the patient was intubated and had changes suggestive of pneumonia (e.g. new, progressive or persistent infiltrate or consolidation). Where radiology reports suggested possible infection or postsurgical atelectasis, only progressive changes were noted; and at least one of the following:

(a) Positive quantitative culture from a bronchial alveolar lavage with ≥10⁵ cfu/mL of potentially pathogenic organisms; or:

(b) Positive blood culture with an organism identical to that isolated from the lower respiratory tract with no other apparent source of infection.

Peripheral-line-associated BSIs were not determined as local signs and symptoms of infection are required to define these infections, whereas this study was focused on infections that were identifiable using microbiological or radiological criteria only. Nevertheless, the risk of developing BSI associated with the peripheral line is known to be as low as 0.1%. Non-device-associated infections were also identified using the definitions previously developed by Brown et al., i.e. patients receiving anti-infective treatment on the date of the survey, which started >48 h after admission, and who had a positive microbiological or radiological report that suggested newly acquired infection not present within 48 h of admission.

The prevalence of device-associated infections was calculated by dividing the number of the specific device-associated infections by the number of patients with the specific device and multiplying by 100.

Results

The Trust-wide census was conducted between 16 and 19, and 23 and 24 July 2009 and took about 4 h in total. There were 1354 inpatients of whom 42% had a peripheral line, 17% a urinary catheter, 12% a central line, and 3% were ventilated. Peripheral lines and urinary catheters were widely distributed across the different
specialties (Table I). By contrast, 68% of central lines were in one of four specialties, namely renal medicine, haematology, adult and neonatal intensive care; these specialties accounted for only 15% of all patients. Of 38 patients on a ventilator, 26 (68%) were from adult intensive care.

Concurrently, the prevalence survey of antimicrobial prescribing found that 495 patients (37% of all 1354 inpatients) were receiving one or more antimicrobials. Of these, 253 (51%) were receiving an antimicrobial for treatment that started >48 h after admission. Table II shows the overall distribution of all 120 HAI-s identified in 104 of these patients (prevalence of 7.7% patients with HAI). UTI and surgical site infection were the most common infections, both with a prevalence of 1.6 infections per 100 patients, followed by BSI (1.3%), gastrointestinal infection (1.0%), and pneumonia (0.9%).

Of the 253 patients receiving antimicrobial treatment that started >48 h after admission, 189 had one or more devices in place on the date of the survey. Sixty-two of these, with only a peripheral line, were excluded, leaving 127 (9.4% of all patients surveyed) with central line(s), urinary catheter or ventilator in place, who were assessed for the presence of device-associated infection. An additional 45 patients receiving antimicrobials for the treatment of BSI, UTI or pneumonia but without a device in place associated with this infection on the day of the survey were also assessed for device-associated infection. For 172 patients (13% of all patients surveyed), it took about 5 min per patient to check electronic microbiology and/or radiology data together with antibiotic treatment and dispensing and discharge diagnoses. Overall, in a previous study, this method showed a sensitivity and specificity from 47% to 99%. Leth and Møller showed that, compared with traditional methods, the use of computerised microbiology and radiology data together with antibiotic treatment to define HAI had a sensitivity of 94% and a specificity of 47%.

Compared with traditional prevalence surveys, our method based on antimicrobial prevalence surveys and electronic data to obtain an estimate of the prevalence of device-associated infection has advantages. First, prevalence surveys of antimicrobial use are quicker than prevalence surveys of HAI. In a recent study, a prevalence survey of antimicrobial prescribing took half the time (55 h) of that of a prevalence survey of HAI (106 h). Second, with our method, only a small proportion of all patients (13%) need to be assessed for the presence of HAI. Also, by focusing on potentially preventable HAI-s such as device-associated infection, even fewer (only 13%) patients needed individual assessment. Third, the method relies on existing information and can be repeated more easily. The pharmacists at ICHT routinely perform a point prevalence survey of antimicrobial prescribing twice yearly. Electronic data can be collected at any time without disrupting ward personnel, and the collection is less prone to transcription errors and only takes about 5 min per patient, saving infection prevention and control time for other tasks. Fourth, the diagnostic criteria are more objective and consistent over time, giving opportunities for benchmarking. Overall, in a previous study, this method showed a sensitivity of 100% and specificity of 97% for the detection of HAI, took two-thirds of the time and was one-third cheaper when compared with the 2006 UK prevalence survey protocol for HAI.

One of the limitations of this method is that the diagnosis of HAI is dependent on positive microbiology or radiological criteria, thereby

### Table I

#### Distribution of devices by specialty

<table>
<thead>
<tr>
<th>Specialties</th>
<th>No. (%) of patients surveyed (N = 1354)</th>
<th>No. (%) of patients with:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Peripheral line (N = 566)</td>
</tr>
<tr>
<td>Medical</td>
<td>425 (31.4)</td>
<td>178 (31.4)</td>
</tr>
<tr>
<td>Elderly medicine</td>
<td>187 (13.8)</td>
<td>46 (8.1)</td>
</tr>
<tr>
<td>Renal</td>
<td>89 (6.6)</td>
<td>47 (8.3)</td>
</tr>
<tr>
<td>Haematology</td>
<td>26 (1.9)</td>
<td>6 (1.1)</td>
</tr>
<tr>
<td>Surgical</td>
<td>253 (18.7)</td>
<td>135 (23.9)</td>
</tr>
<tr>
<td>Mixed medical and surgical</td>
<td>139 (10.3)</td>
<td>58 (10.2)</td>
</tr>
<tr>
<td>Gynaecology and obstetrics</td>
<td>115 (8.5)</td>
<td>38 (6.7)</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>32 (2.4)</td>
<td>17 (3.0)</td>
</tr>
<tr>
<td>Adult intensive care</td>
<td>51 (3.8)</td>
<td>26 (4.6)</td>
</tr>
<tr>
<td>Neonatal intensive care and special care</td>
<td>33 (2.4)</td>
<td>11 (1.9)</td>
</tr>
<tr>
<td>Paediatric intensive care</td>
<td>4 (0.3)</td>
<td>4 (0.7)</td>
</tr>
</tbody>
</table>

### Table II

#### Prevalence of healthcare-associated infections among 1354 patients

<table>
<thead>
<tr>
<th>Type of infection</th>
<th>No. (%) of infections</th>
<th>Prevalence (%) per 100 infections surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical site</td>
<td>22 (18.2)</td>
<td>1.6</td>
</tr>
<tr>
<td>Urinary tract</td>
<td>22 (18.2)</td>
<td>1.6</td>
</tr>
<tr>
<td>Bloodstream</td>
<td>17 (14.0)</td>
<td>1.3</td>
</tr>
<tr>
<td>Gastrointestinal tract</td>
<td>13 (10.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>12 (10.7)</td>
<td>0.9</td>
</tr>
<tr>
<td>Lower respiratory tract</td>
<td>8 (6.6)</td>
<td>0.6</td>
</tr>
<tr>
<td>Local vascular access</td>
<td>8 (6.6)</td>
<td>0.6</td>
</tr>
<tr>
<td>Others</td>
<td>18 (14.9)</td>
<td>1.3</td>
</tr>
<tr>
<td>Total</td>
<td>120 (100)</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Discussion

During the last decade, new approaches to surveillance have been developed that use existing electronic databases such as patient information systems, microbiology results, antimicrobial dispensing and discharge diagnoses. These automatic methods have shown a good sensitivity and specificity when compared with traditional methods. In a recent systematic review, Leal and Laupland identified 24 studies that compared the utility of electronic surveillance with conventional surveillance and found that the sensitivity of electronic surveillance for detecting HAI ranged from 59% to 96% and the specificity from 47% to 99%. Leth and Møller showed that, compared with traditional methods, the use of computerised microbiology and radiology data together with antibiotic treatment to define HAI had a sensitivity of 94% and a specificity of 47%.

Compared with traditional prevalence surveys, our method based on antimicrobial prevalence surveys and electronic data to obtain an estimate of the prevalence of device-associated infection has advantages. First, prevalence surveys of antimicrobial use are quicker than prevalence surveys of HAI. In a recent study, a prevalence survey of antimicrobial prescribing took half the time (55 h) of that of a prevalence survey of HAI (106 h). Second, with our method, only a small proportion of all patients (13%) need to be assessed for the presence of HAI. Also, by focusing on potentially preventable HAI-s such as device-associated infection, even fewer (only 13%) patients needed individual assessment. Third, the method relies on existing information and can be repeated more easily. The pharmacists at ICHT routinely perform a point prevalence survey of antimicrobial prescribing twice yearly. Electronic data can be collected at any time without disrupting ward personnel, and the collection is less prone to transcription errors and only takes about 5 min per patient, saving infection prevention and control time for other tasks. Fourth, the diagnostic criteria are more objective and consistent over time, giving opportunities for benchmarking. Overall, in a previous study, this method showed a sensitivity of 100% and specificity of 97% for the detection of HAI, took two-thirds of the time and was one-third cheaper when compared with the 2006 UK prevalence survey protocol for HAI.
Prevalence of device-associated infections

<table>
<thead>
<tr>
<th>Type of device</th>
<th>No. of patients with this device</th>
<th>No. of patients with device-associated infection</th>
<th>Type of device-associated infection (and % prevalence per 100 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary catheter</td>
<td>228</td>
<td>9</td>
<td>CAUTI (3.9)</td>
</tr>
<tr>
<td>Central line</td>
<td>159</td>
<td>5</td>
<td>CLABSI (3.1)</td>
</tr>
<tr>
<td>Ventilator</td>
<td>26†</td>
<td>3</td>
<td>Local vascular access infection-associated with central line (3.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>VAP† (11.5)</td>
</tr>
</tbody>
</table>

CAUTI, catheter-associated urinary tract infection; CLABSI, central-line–associated bloodstream infection; VAP, ventilator-associated pneumonia.

* Adult intensive care patients.

depending on the frequency with which these tests are performed. In addition, the diagnosis of HAI based on positive microbiology or radiological criteria only may underestimate or overestimate the prevalence of these infections. Finally, in any prevalence survey of device-associated infection it may be difficult to determine whether the device preceded the infection, was in place simultaneously with the infection, or had been removed as a consequence of the associated infection. Rosello-Urgell et al. found that collecting data on the presence of devices on the date of the survey was as valid as collecting information within the seven days before the survey. In our study, we tried to overcome this limitation by reviewing patients receiving antimicrobials for BSI, UTI and pneumonia but without the specific-associated device in situ on the day of the survey, and we determined whether they still met the criteria for device-associated infection. For example, we found three patients with UTI, but without a urinary catheter on the day of the survey, though the urine sample had been taken from a urinary catheter.

Although the main purpose of this study was to evaluate this method for determining the prevalence of device-related infection, some of our findings raise issues of general interest. Overall, our results were quite similar to the 2006 UK national prevalence survey. For example, we found that the prevalence of patients with one or more HAI was 7.7%, very similar to 2006 UK national prevalence of 7.6%, and to that previously found by Brown et al. (8.3%) in the same Trust, using the same methodology.

Surveillance and prevention of CLABSI are usually focused on intensive care, and there is little information about the prevalence of these infections in other specialties. In addition to the adult intensive care unit where 23% of patients had one or more central lines, renal and haematology accounted for 30% and 9% of the central lines used, respectively. All local vascular access infections associated with the central line occurred in renal and adult intensive care. Compliance with best clinical practices, as indicated in healthcare bundles and our local healthcare processes, for central line insertion and care should be emphasised in all these specialties in order to prevent such infections.

Although the use of urinary catheters was widely distributed across the Trust, medical patients were more likely to have a urinary catheter (43% of patients in the survey) and they accounted for 77% of the CAUTIs. Care of the elderly alone accounted for one-third of these infections and prevention programmes should be a priority in this patient group. Although 67% of intensive care patients had an indwelling urinary catheter, no CAUTIs were identified.

Only 2.0% (26 patients) of all adult patients were on mechanical ventilation, but VAP had the highest prevalence of all device-associated infections (11.5%), and contributed to 25% of all pneumonias. However, pneumonia is the most difficult HAI to measure accurately because the diagnosis is complicated and prone to subjective judgement. As mechanical ventilation is restricted to intensive care patients, prospective surveillance would be more appropriate than prevalence surveys.

In conclusion, point prevalence surveys of antimicrobial prescribing in accordance with standardised methodology such as ESAC, together with existing electronic microbiology, and radiology reports, constitute a simple means of expediting sequential prevalence surveys of device-associated infections and give opportunities for benchmarking. These surveys, together with surveys on device use, provide hospital-wide information on the use of devices, and on the prevalence and trends of device-associated infections. In future, other hospitals might also consider this use of antimicrobial prescribing data, and come to a consensus on the definitions of device-related infection used in this study. It should be possible to gain access to microbiology and radiology electronic databases and estimate the potential time and cost savings of the use of this method in individual hospitals. The method needs to be developed into an automatic system that integrates microbiology data, radiology reports and discharge diagnosis and that uses computer algorithms for device-associated infection.

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Conflict of interest statement

None declared.

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