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Costs associated with hospital-acquired bacteraemia in a Belgian hospital

M. Pirson[a,*], M. Dramaix[b], M. Struelens[c], T.V. Riley[d], P. Leclercq[a]

[a]*Department of Health Economics, School of Public Health, Université Libre de Bruxelles, 806 Route de Lennik, B1070 Brussels, Belgium*
[b]*Biostatistics, School of Public Health, Université Libre de Bruxelles, 806 Route de Lennik, B1070 Brussels, Belgium*
[c]*Department of Microbiology, Université Libre de Bruxelles—Erasme Hospital and Epidemiology of Infection Unit, 808 Route de Lennik, B1070 Brussels, Belgium*
[d]*Department of Microbiology, The University of Western Australia and Western Australian Centre for Pathology and Medical Research, Nedlands 6009, Australia*

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Summary Studies from around the world have shown that hospital-acquired infections increase the costs of medical care due to prolongation of hospital stay, and increased morbidity and mortality. The aim of this study was to determine the extra costs associated with hospital-acquired bacteraemias in a Belgian hospital in 2001 using administrative databases and, in particular, coded discharge data. The incidence was 6.6 per 10 000 patient days. Patients with a hospital-acquired bacteraemia experienced a significantly longer stay (average 21.1 days, $P<0.001$), a significantly higher mortality (average 32.2%, $P<0.01$), and cost significantly more (average €12 853, $P<0.001$) than similar patients without bacteraemia. At present, the Belgian healthcare system covers most extra costs; however, in the future, these outcomes of hospital-acquired bacteraemia will not be funded and prevention will be a major concern for hospital management.

Introduction

Surveillance for hospital-acquired infections is undertaken in many countries throughout the world with the overall prevalence varying from 6% to 12%.[1–8] These infections add significant extra

* Corresponding author. Tel./fax: +32-2-555-40-56.
E-mail address: magali.pirson@ulb.ac.be

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costs to the healthcare sector.[9-11] After controlling for confounding effects, such as severity of illness, average excess costs of about US$ 15 275 per case for confirmed hospital-acquired infections have been estimated.[12]

The incidence of hospital-acquired bacteraemia ranges from 0.27% to 4.9% of admissions[13-19] or eight infections per 10 000 days of stay.[13-19] Bacteraemias comprise only about 8% of all hospital-acquired infections,[15] but they increase the length of stay (LOS) by 7–21 days,[20] and result in a crude mortality of 16.3–35%.[20] In a recent UK study of all hospital-acquired infections, patients with hospital-acquired bacteraemia, on average, incurred costs 4.3 times higher than uninfected patients, equivalent to an additional £5397. However, in this study, only four patients acquired a bloodstream infection and no other infection, two of whom died during the inpatient period. A further 11 patients acquired a bloodstream infection and one or more infections at other sites, giving an overall incidence of 0.4%.[21]

These complications are higher still when the bacteraemia is caused by an antibiotic-resistant micro-organism such as methicillin-resistant *Staphylococcus aureus* (MRSA), with mortality rates increasing to 20–64%.[22-24]

In Belgium, the Scientific Institute of Public Health Epidemiology Unit reported a bacteraemia incidence of 7.6 infections per 10 000 days of stay between 1992 and 2001 (8.0 in 2000–2001). Large hospitals ($\geq$500 beds) had a higher incidence (8.1/10 000 patient days) than medium-sized hospitals (250–499 beds) (6.6/10 000 patient days). In Belgian intensive care units (ICUs), the incidence was over six times higher than in other units, while the overall mortality was about 31.4%. Hospital-acquired bacteraemias are a particular problem in ICUs or in neutropenic patients,[25] where the mortality can vary from 31.5 to 82.4%, with an increase in LOS of about 10 days,[26] and increased costs of about €35 000–40 000.[14,26]

The aim of this study was to determine the costs associated with bacteraemias at a Belgian general hospital and to determine the impact of those costs on the Belgian health system.

Methods

Setting

The general hospital was situated in Brussels and had 278 beds. During 2001, there were 8169 multiday stay discharges. Services included general surgery and medicine, paediatrics, psychiatry and geriatrics, and specialized services such as chronic diseases, cardiac and pulmonary diseases, orthopaedics and palliative care. The hospital catered for both private and public patients.

In this study, all adult admissions except obstetric cases were analysed (N=8169) because it was difficult to separate costs related to the mother's admission from those of the baby.

Case/control finding and definitions

The hospital infection control practitioner provided an extract from the NSIH (National Surveillance of Infections in Hospitals) local database, listing patients with a hospital-acquired bacteraemia (cases) for 2001. Hospital-acquired bacteraemia was defined as an infection that developed 48 h after hospital admission. One positive blood culture for a patient with clinical signs, with a central venous catheter and who was prescribed specific antibiotics was considered as a hospital-acquired bacteraemia. If the bacteraemia was caused by a cutaneous micro-organism, at least two positive blood cultures within a 72-h period with the same organism were required.[27] Microbiological data were extracted from the same database including site of infection, hospital service and infecting micro-organism. Controls were all patients with the same diagnosis-related group [all patients refined diagnosis-related group (APR-DRG)] but without a hospital-acquired bacteraemia.

DRGs are a patient classification system that was originally developed as a means of relating the type of patient that a hospital treats to the costs incurred by the hospital.[28] The APR-DRG[29-31] is a modification of the original DRG system. DRGs are assigned using the principal diagnosis and additional diagnosis codes, the principal procedure and additional procedure codes, age, sex and discharge status. One DRG is assigned for each inpatient stay. The APR-DRG further refines the basic DRG by adding four subgroups of severity of illness (and the risk of mortality). Severity of illness is defined as the extent of organ system loss of function or physiological decompensation. The four severity of illness subgroups represent minor (1), moderate (2), major (3) or extreme (4). The assignment of a patient to one of these four subgroups takes into consideration not only the specific secondary diagnoses but also the interaction between secondary diagnoses, age, principal diagnosis and procedures. The determination of the severity of illness is disease specific, and high severity of illness is primarily determined by the interactions

of multiple diseases. Importantly, APR-DRGs are determined at the end of the stay.

Data analysis

The following variables were analysed for both groups: LOS, severity score, mortality rate, overall costs, drug costs, antimicrobial costs, overall medical costs, and specific medical costs by service (anatomical pathology, blood bank, cardiology, general surgery, general medicine, orthopaedic surgery, plastic surgery, dermatology, haemodialysis, endocrinology, gastroenterology, emergency care, nuclear medicine, radiology, vascular surgery, physiotherapy, laboratory medicine, neurology, ear/nose/throat surgery, paediatrics, respiratory medicine, psychiatry, anaesthesia, rheumatology, stomatology and urology).

For some analyses, patients were grouped into six bigger groups, largely based on systems (respiratory, vascular, digestive, orthopaedics, neoplastic, others), to overcome the problem of groups with too few patients to analyse.

Data linkages were performed using Access 2000 (Microsoft) and TM1 (Applix) software.

Cost analysis

Cost analyses were done retrospectively using accountancy data from various hospital cost centres, medical records data and invoicing data. Some costs were estimated and others were calculated directly for the admission. Administrative cost centres (admitting, invoicing, accountancy, management) and general services cost centres (laundry, housekeeping, sterilization, small care consumables) were estimated through cost drivers, such as medical charges and LOS tempered by medical and drugs charges. With this method, the total service department costs were divided by the total work outputs to calculate unit costs. The total cost for each patient, estimated by this method, was calculated by multiplying the quantity of each resource used by the unit cost of that resource, then summing all resource costs.

Nursing costs were available by cost centre and estimated for patients based on LOS (80% of the cost) plus 10% from both medical and drug consumption costs that were known from invoicing records. This was done because a daily nursing workload record is not kept in Belgium. Medical costs (medical procedures and drugs) were retrieved directly from invoicing records.

Statistical analysis

Statistical analysis was performed using SPSS Version 12 software. Continuous variables are described as mean, [standard deviation (SD)] and median. Comparative tests on categorical variables were executed with Pearson's χ^2 test or Fisher's exact test, and the Mann–Whitney test was used for continuous variables (asymmetrical distribution for costs and LOS).

Results

Incidence rate

In 2001, 46 cases fulfilled the definition of a hospital-acquired bacteraemia, giving an incidence of 0.56% or 6.6 per 10 000 days.

Case mix

Cases were grouped into 14 major disease categories and 30 APR-DRGs (Table I), and hospitalized in several services: general and abdominal surgery (25%), internal medicine (22%), intensive care (17%), orthopaedics (14%), cardiovascular surgery (11%), oncology/haematology (6%) and urology (6%).

Cause and source of hospital-acquired bacteraemia

Micro-organisms responsible for the hospital-acquired bacteraemias were coagulase-negative staphylococci, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* (Table II). Sources were: central venous catheter (19.4% of cases), peripheral catheter (2.8%), invasive procedure (2.8%), foreign body (2.8%), unknown (8.3%) and other (63.9%), i.e. urinary tract infection, surgical-site infection, intra-abdominal and respiratory infections.

LOS

The mean LOS for cases was 34.6 days (SD 18.9 days), and the median was 32 days. For controls, the mean LOS was 13.5 days (14.7 days), and the median was 9 days ($P<0.001$). Fourteen patients (38.8%) with a hospital-acquired bacteraemia went to the ICU, compared with 103 (7.8%) controls ($P<0.001$). The mean LOS for patients in the ICU was 14.9 days (14.8 days) (median: 8.8 days), compared

Table I Case mix of the sample

APR-DRGs		*N*	Without bacteraemia	With bacteraemia
004	Tracheostomy except for face, mouth and neck diagnoses	3	2	1
045	CVA with infarction	86	85	1
121	Non-major respiratory procedures	18	17	1
122	Other respiratory system procedures	4	3	1
130	Respiratory system diagnosis with ventilator support 96 h+	13	11	2
140	Chronic obstructive pulmonary disease	125	124	1
173	Other vascular procedures	83	82	1
196	Cardiac arrest, unexplained	8	7	1
206	Malfunction, reaction and complications of cardiac or vascular device or procedures	6	5	1
221	Major small and large bowel procedures	77	75	2
225	Appendectomy	146	145	1
229	Other digestive system procedures	11	10	1
260	Pancreas, liver and shunt procedures	4	3	1
261	Major biliary tract procedures	6	4	2
280	Cirrhosis and alcoholic hepatitis	60	59	1
282	Disorders of pancreas except malignancy	30	29	1
308	Hip and femur procedures except major joint for trauma	102	100	2
313	Knee and lower leg procedures except foot	203	202	1
341	Fracture of pelvis or dislocation of hip	30	29	1
347	Medical back problems	80	79	1
380	Skin ulcers	10	9	1
382	Malignant breast disorders	11	10	1
460	Renal failure	43	41	2
482	Transurethral prostatectomy	14	13	1
691	Lymphoma and non-acute leukaemia	29	27	2
693	Chemotherapy	39	38	1
710	Procedures for infectious and parasitic diseases	5	4	1
757	Organic disturbances and mental retardation	52	51	1
791	Procedures for complications of treatment	20	19	1
950	Extensive procedure unrelated to principal diagnosis	26	25	1
Totals		1344	1308	36

with 7.7 days (9.2 days) (median: 4.1 days) for controls; a mean extra LOS of 7.2 days.

Severity score

The majority of patients (67%) who acquired a bacteraemia had the highest severity score (4); only 11% of controls had such a score ($P<0.001$) (Figure 1).

Mortality rate

Over one-third of cases (36%) died, compared with 6% of controls with the same APR-DRG but without bacteraemia ($P<0.001$). Thus, the mean excess mortality was 30%. Of the 14 patients who went to the ICU, nine (64%) died, while 103 of 1308 controls went to the ICU and 33 died (32%). The excess mortality was 32.3% ($P=0.01$).

Cost analysis

The mean cost for cases was €18 288, while it was €5440 for similar patients without a hospital-acquired bacteraemia. The extra cost associated

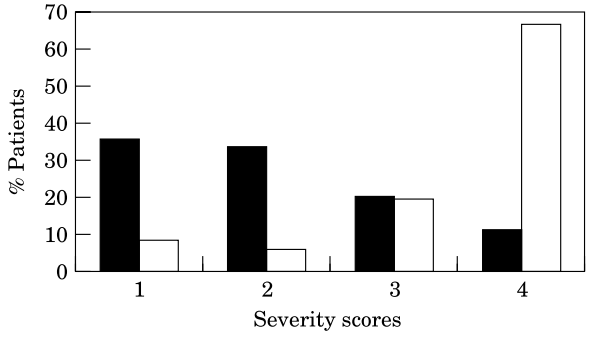

Figure 1 Severity score differences between infected (open bars) and non-infected (solid bars) patients ($N=1344$).

Table II Micro-organisms responsible for episodes of hospital-acquired bacteraemia

Micro-organisms	*N*	%
Coagulase-negative staphylococci	8	22.2
Escherichia coli	7	19.4
Staphylococcus aureus	6	16.6
Pseudomonas aeruginosa	4	11.1
Enterobacter cloacae	2	5.6
Bacteroides distasonis	1	2.8
Bacteroides fragilis	1	2.8
Candida albicans	1	2.8
Candida glabrata	1	2.8
Enterobacter aerogenes	1	2.8
Hafnia alvei	1	2.8
Klebsiella pneumoniae	1	2.8
Morganella morganii	1	2.8
Proteus mirabilis	1	2.8

with hospital-acquired bacteraemia was €12 853 per patient, an increase of 236% ($P<0.001$) (Table III). The mean cost for cases who went to the ICU was €29 285, while for controls, it was €17 842, an increase of €11 443 ($P=0.008$).

Extra costs for patients with hospital-acquired bacteraemia were observed in all groups (Table III); however, increases were more marked for some systems. The costs were 300% extra for the digestive system and 81% extra for the vascular system. To determine whether the extra costs were simply the result of an increased LOS, non-medical costs (essentially influenced by the LOS) and medical costs (medical practice and drugs) were compared (Table III). Medical and non-medical costs increased in the same proportion and each accounted for about 50% of the extra costs. Patients who acquired a bacteraemia in hospital had more medical treatments, especially in anatomical pathology, laboratory medicine, nuclear medicine, radiology, blood bank, cardiology, internal medicine, dermatology, haemodialysis, gastroenterology, vascular investigation, physiotherapy and psychiatry. Furthermore, the costs for drugs were higher for patients with a hospital-acquired bacteraemia, especially antibiotic costs (Table IV).

Nearly 40% of cases incurred total costs that were higher than the total reimbursement (from all sources) received by the hospital. Therefore, for all 36 patients with hospital-acquired bacteraemia, the hospital lost €56 290, an average of €1564 per case (Table III).

Discussion

Calculating the cost of hospital-acquired infections can be difficult in many institutions due to lack of,

Table III Mean total extra costs (CT), medical costs (CM), non-medical costs (CNM) and reimbursement for hospital-acquired bacteraemias ($N=1344$)

System	Bacteraemia	Mean CM (€)	Mean CNM (€)	Mean CT (€)	Reimbursement (€)
Vascular	Without	2845.3	3816.5	6661.8	7390.33
	With	6241.8	5802.1	12 043.9	10 998.54
	Difference	3396.5 (63.1%)	1985.6 (36.9%)	5382.1	3608.21
Respiratory	Without	3816.3	5259.7	9076.0	9196.24
	With	10 052.9	13 045.6	23 098.5	15 906.97
	Difference	6236.6 (44.5%)	7785.9 (55.5%)	14 022.5	6710.73
Orthopaedic	Without	1587.1	2080.1	3667.2	4325.85
	With	6592.5	5344.8	11 937.3	13 683.92
	Difference	5005.4 (60.5%)	3264.6 (39.5%)	8270.1	9358.07
Neoplastic	Without	2019.3	1668.6	3687.9	4257.65
	With	6597.1	6260.9	12 858.0	13 890.35
	Difference	4577.8 (49.9%)	4592.3 (50.1%)	9170.1	9632.7
Digestive	Without	2504.8	2797.7	5302.6	5585.61
	With	10 788.3	11 160.7	21 949.0	19 749.39
	Difference	8283.4 (49.8%)	8362.9 (50.2%)	16 646.4	14 163.78
Others	Without	2438.2	3660.3	6098.5	6993.58
	With	10 929.8	9436.5	20 366.3	20 113.07
	Difference	8491.6 (59.5%)	5776.2 (40.5%)	14 267.8	13,119.49
Total	Without	2472.18	2962.72	5434.9	5972.14
	With	8624.34	9663.34	18 287.68	16 724.06
	Difference	6152.15 (47.9%)	6700.63 (52.1%)	12 852.78	10 751.92

Table IV Mean of extra drug costs (€) by pathology types ($N=1344$)

System/group	Without bacteraemia			With bacteraemia		
	Total drug costs	Antibiotic costs	%	Total drug costs	Antibiotic costs	%
Digestive	921.0	227.8	24.7	5327.9	1858.4	34.9
Neoplastic	1055.9	99.0	9.4	3607.6	859.2	23.8
Orthopaedic	339.0	77.4	22.8	2981.5	2016.1	67.6
Respiratory	1569.0	580.9	37.0	5373.5	1706.5	31.8
Vascular	655.7	139.4	21.3	3972.9	731.2	18.4
Others	798.9	209.5	26.2	4402.9	1625.4	36.9

or poor access to, relevant financial data. However, with the Belgian system of invoicing patients directly for many items, all medical procedures and medications are recorded for each patient and it is not difficult to calculate costs for them. While there are data available for other costs, some were estimated with cost drivers and by calculating unit costs. This is not as precise as collecting individual patient-level data, but these estimates are valuable for gaining some understanding of the total direct costs of hospital-acquired infections, particularly bacteraemias.

The extra cost associated with hospital-acquired bacteraemias was €12 853 per patient. This figure is similar to that reported in other studies[14,26,32,33] but more than that reported in an earlier Belgian NSIH study.[34] Based on US cost data, hospital-acquired bacteraemias in Belgium appeared to add €2287 per infection, and to cost about €92 960 072 nationally, without indirect costs in 1998.[34] The reasons for this discrepancy are unclear. In Italy, Orsi *et al*. estimated an increase in costs of about €16 354 using multiplication of an average charge per day with the increased LOS;[32] however, a similar increase in cost was calculated. In the USA, Abramson and Sexton[33] estimated an increase in costs of about $9661 for hospital-acquired methicillin-susceptible *Staphylococcus aureus* and $27 083 for hospital-acquired MRSA.

These increases in costs can, in part, be explained by the average increase in LOS (over 21 days) for bacteraemic patients; however, other factors such as drug and medical costs also contributed. Antibiotic costs, procedure costs and laboratory costs were significantly higher for patients that acquired a bacteraemia (€549 vs €3283). While this seems logical, increased costs for some other resources cannot be explained so easily. For example, there were significantly increased costs for psychiatric services.

The extra LOS and high mortality rate in this study are near the maxima reported in Belgian and foreign literature. Both these figures will be influenced by the severity score. Cases had a markedly worse severity score than controls; however, because the severity score was determined at discharge, and is related to comorbidities, it is difficult to determine whether cases had a high score at admission or if the bacteraemia resulted in a higher severity score. Digiovine *et al*. reported no difference in mortality when they adjusted for severity scores,[26] and it may be that costs attributable to hospital-acquired bacteraemia are less when adjusted for severity of the underlying illness. However, their study was undertaken on intensive care patients. It would be better if costs could be calculated on a daily basis rather than for the complete LOS. In this way, the extra costs specifically attributable to the bacteraemia would be more apparent.

This study has allowed us to comment on the quality of ICD-9CM coded discharge summaries at the hospital from which the APR-DRGs and funding were determined. Of the 36 cases of bacteraemias determined by the Infection Control Department, only 19 (53%) had a secondary diagnosis of bacteraemia. For the other 17 cases, 10 had one or more infectious diagnoses codes, while seven had none. This is significantly better than a recently published study from Italy in which the sensitivity of coded discharge data was only 10% for surgical-site infections.[35] Nonetheless, incorrect coding can influence the severity score and thus the amount of money allocated in the Belgian system. This also means that the severity score analysis may not be completely accurate and it is likely that some cases had a higher severity score than that recorded.

Our study has several limitations. First, it was a retrospective study based solely on administrative databases containing financial and other data. However, there is a worldwide trend to start validating such information for infection control purposes, usually because it is readily accessible, easily extracted and requires little extra

manipulation. Apart from the Italian study mentioned above,[35] several other recent studies have suggested that routine discharge data can have a role in supporting infection control programmes, particularly for surveillance purposes,[36,37] although this is likely to be region or facility specific.

Studies using APR-DRGs may be difficult to analyse because patients are grouped into 355 APR-DRG groups, and if the sample size is too small, the groups often comprise too few patients and statistical analyses are difficult. Therefore, conclusions must be reached carefully. In the present study, 30 APR-DRGs were represented among cases and, in all but four cases, there were more than four controls available per case. A traditional pairwise-matched analysis was not done because factors that would have been used for pairing are used to constitute the APR-DRG, such as primary diagnosis, number of other diagnoses, age, etc. Finally, as already alluded to above, our results should be interpreted carefully because it is likely that additional factors as well as bacteraemia contribute to the increased LOS and cost. In many cases, the bacteraemia may be a marker of a different underlying problem which leads to the bacteraemia.

In summary, with the funding arrangements in Belgium in 2001, an allocation system based on LOS adjusted by national average per APR-DRG and on reimbursement of medical and drug prices, there was a good correlation between extra costs and charges for 61% of patients, provided that the hospital was around the national average for LOSs for similar APR-DRGs. For healthcare departments, recognition of the extra costs of hospital-acquired infections is important because they result in more costs than reimbursement. In future, because the allocation of resources will be more based on case mix, hospitals with a higher rate of hospital-acquired infections will be economically penalized. Hospital administrators should be aware of this. In such a context, investment should be made in developing systems to prevent infections. Ultimately, they will be generating profit because infection prevention programmes can prevent up to one-third of infections.[17]

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