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Assessment of Costs Associated with Hospital-Acquired Infections in a Private Tertiary Care Hospital in India

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ABSTRACT

Objective: This study aims to assess the costs associated with hospital-acquired infections (HAIs) in a private tertiary care hospital in northern India. **Methods:** This retrospective case-control study covered four types of HAIs: urinary tract infections, ventilator-associated pneumonia, bloodstream infections, and surgical site infections. The "case" group comprised patients who had developed HAIs, whereas the "control" group had patients who had not acquired HAIs. The control group was matched with the case group on the criteria of age, diagnosis, and severity of illness. Drugs' acquisition costs, hospital rental, consultation fees, investigation costs, and antimicrobial costs were computed for patients over a period of 1 year, and comparisons were made between both the arms of the study. The costs were also compared within the different HAIs. **Results:** Of the four types of HAIs studied, the most commonly encountered infection was bloodstream infection (38%). The pathogen most frequently responsible for causing HAIs was *Acinetobacter baumanii*. Patients aged between 60 and 69 years were found to be more susceptible to HAIs than the patients in other age groups. Furthermore, the most common diagnosis of patients who developed HAI was head injury followed by renal failure. Drugs' acquisition costs, rent, consultation fees, investigation costs, and antimicrobial costs were significantly higher for cases than for controls ($P < 0.001$). Drugs' acquisition cost was the major contributor of the extra cost, and antimicrobial drugs constituted almost half of it. **Conclusions:** This study has provided evidence that the cost of drugs is a major contributor to costs of HAIs in an Indian setting. Continuous surveillance and prophylaxis is recommended for reducing HAIs.
Keywords: bloodstream infection, costs, hospital-acquired infections, urinary tract infection, ventilator-associated infection.

Introduction

Congregating a large number of patients under a single roof could easily facilitate the transmission of infectious diseases from one patient to another. The chances of developing an infection increases manifold if the patient is immunocompromised or has an inserted medical device (such as urinary catheter, ventilator, or central lines).

Approximately 5% of hospitalized patients experience a hospital-acquired infection (HAI) [1]. HAI, according to the Centers for Disease Control and Prevention guidelines, is a localized or systemic condition 1) that results from adverse reaction to the presence of an infectious agent(s) or its toxin(s) and 2) that was not present or incubating at the time of admission to the hospital [2]. HAIs are an important public health problem in developing countries as well as in developed ones. HAI is known to be a major cause of high morbidity, mortality, and economic consequences in hospitalized patients [1].

At any time, more than 1.4 million people worldwide suffer from complications of infections acquired in the hospital [3]. HAIs could lead to any one or more of these: functional disability and emotional stress to the patient, increased morbidity (serious consequences and permanent disability), and prolongation of hospital stay, which adds to the cost. Developed countries, over a period of time, have established standardized criteria for the surveillance and control of HAIs. In developing countries, however, only limited results are available to understand the cost of HAIs and there is a lack of surveillance of HAIs [4,5].

A retrospective case-control study, conducted at the cardiothoracic unit of a 200- bed Indian tertiary care hospital, has provided evidence that patients with hospital-acquired bacteremia had a statistically significantly longer total hospital stay and intensive care unit stay.

These results also demonstrated that hospital-acquired bacteremia significantly increases mortality and costs of hospitalization in lower-income developing countries. It was concluded that the costs associated with HAIs are similar between developing and developed countries [6].

The aim of this study was to assess the costs associated with HAIs in a private tertiary care hospital in northern India.

Methods

The study was conducted at a private tertiary care hospital with a capacity of 250 beds. It is understood that 70% of the patients

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paid for their costs out of their own pocket and only 30% of the patients were covered under a reimbursement scheme or insurance. Annually, the hospital handles close to 20,000 inpatient admissions.

Study Design

It was a retrospective study wherein the patients were divided into two groups:

1. The "case" group included inpatients who had developed an HAI.
2. The "control" group included inpatients who had not developed an HAI.

The patients in the two arms were matched on the basis of age, diagnosis, and severity of illness as evaluated by the Acute Physiology and Chronic Health Evaluation IV scoring system [7].

Time period

The records of patients admitted to the hospital from August 2008 to July 2009 were screened, and only those meeting the inclusion and exclusion criteria were included in the study. An HAI was defined as one that was neither present nor incubating at the time of admission and occurred only after 48 hours of admission to the hospital.

Inclusion criteria

Inpatients 18 years or older, either sex, with a minimum hospital stay of 48 hours were included. Only the culture-positive patients were included.

Exclusion criteria

Patients who had infectious diseases or had only symptoms of infection but had negative cultures were excluded. Furthermore, patients with suspected clinical signs of HAI but with negative culture report, patients admitted for labor, and patients with the diagnosis of sepsis or septic shock were excluded.

Data Collection

The data were collected by using patient medical records, hospital information system, and other administrative databases for costs and outcome analysis.

The data included patients' information such as age, sex, date of admission, discharge, surgery, diagnosis and surgical procedure/intervention and date of infection, type of infection, pathogens, and antimicrobial drugs (AMDs) prescribed.

The data related to the cost component of the study included package cost offered by the hospital plus costs incurred on consumables, hospital room rent, drugs, investigations, blood components, consultation, and AMDs.

Data Analysis

The infection rates for central venous catheter-associated bloodstream infection (BSI), catheter-associated urinary tract infection(UTI), and ventilator-associated pneumonia (VAP) were determined according to Centers for Disease Control and Prevention-National Nosocomial Infections Surveillance definition [1,8].

All data were organized by using a spreadsheet. Continuous variables were reported as average ± standard error of the mean. They were compared by using student's *t* test, or the Wilcoxon rank-sum test when departure from normality was observed.

Table 1 – Demographics and clinical profiles of cases and controls.

Variable	n (%)		*P*
	Cases	Controls	
Total number of patients	108	108	
Men	62 (57)	86 (80)	<0.001
Women	46 (43)	22 (20)	<0.001
Average age of patients (y), mean ± SEM	60 ± 1.7	61 ± 1.5	0.30
Chronic health comorbidities			
Hypertension	28 (25.9)	43 (39.8)	0.0140
Diabetes	15 (13.8)	25 (23.1)	0.0388
Coronary artery disease	8 (7.4)	8 (7.4)	0.5000
Asthma	4 (3.7)	2 (1.8)	0.2034
Others	8 (7.4)	10 (9.2)	0.4900
Profile of diagnoses			
Head injury	31 (28)	31 (28)	
Renal failure	22 (20)	22 (20)	
Vascular	13 (12)	13 (12)	
Respiratory	12 (11)	12 (11)	
Liver	5 (4)	5 (4)	
Gastric	4 (3)	4 (3)	
Neoplastic	4 (3)	4 (3)	
Others	17 (15)	17 (15)	
Discharge status (n = 108)			
Improved	68 (62.9)	91 (84.2)	<0.001
LAMA	9 (8.4)	13 (12.1)	<0.001
Death	31 (28.7)	4 (3.7)	<0.001

LAMA, left against medical advice; SEM, standard error of the mean.

Results

The data of 30 patients were excluded from the study in accordance with the exclusion criteria or unavailability of the matched controls. Therefore, 216 patients' data were analyzed to achieve the objectives of this study.

Both the arms of the study were balanced, with108 patients in each arm of the study. The case group had 57% male patients, while the control group had 80% male patients. The two groups were matched for average age, which was 61 years. Comorbidities such as hypertension, diabetes, coronary artery disease, and asthma were higher in the control group (Table 1).

It was observed that the highest proportion of HAIs occurred in the age group of 60 to 69 years (27%) followed by those in the age group of 70 to 79 years (23%). It was also found that patients with a head injury or those who had undergone neurosurgeries were more prone to develop HAI followed by patients having diseases related to renal failure (28.7% and 20.4%, respectively; Table 1).

In the case group, 41 patients had a central line–associated BSI. The number of patients with ventilator-associated infections and catheter-associated UTIs was very close to each other (33 and 30, respectively); only 4 patients had a surgical site infection (SSI). Multiple HAIs were observed in 13 patients. The infection rate was calculated for BSI, UTI, and VAP and represented as per 1000 device-days. The infection rate was found to be the highest for VAP followed by BSI (6.8 and 3.2, respectively). Furthermore, it was observed that it takes approximately 14 days on average post-admission to develop an HAI (median 11 days; range 2–75 days).

In terms of outcomes, the discharge status was analyzed as improved, left against medical advice (LAMA), or death of the patients. It was found that 31 patients died in the case group against 4 in the control group (Table 1). Furthermore, BSI was found to be the largest contributor to mortality in the case group followed by VAP, UTI, and SSI (15, 11, 4, and 1 deaths, respectively).

A total of 140 microorganisms were identified in 108 infections. A single pathogen was found in 75% of the cases, two pathogens were found in 20% of the cases, and three pathogens were isolated in 5% of the infections. In the hospital, *Acinetobacter baumannii* and *Escherichia coli* were the two most common causative microorganisms for HAIs (45 and 16 patients in the case group, respectively; Table 2).

In the case group, imipenem was the most prescribed AMD (66.6%) followed by metronidazole, piperacillin, levofloxacin, amikacin, and linezolid. In the control group, however, ceftriaxone was the most commonly prescribed AMD followed by ciprofloxacin and piperacillin + tazobactam (28% > 22% > 21%, respectively; Table 3).

Various costs counted in the study were drugs' acquisition cost, hospital room rent, investigation costs, consultation fees, consumables cost, blood components cost, and prescribed antimicrobial costs. The costs are represented as Indian rupees as well as US dollars. It was assumed that US $1 equals Indian rupees 55.

Of all the HAIs, VAP was found to be the most expensive HAI followed by BSI, UTI, and SSI (Table 4). All the components of costs were statistically significantly higher for cases than for controls ($P < 0.001$). The cost for drugs' acquisition was the main cost driver, and the cost of AMDs constituted almost half of the drugs' acquisition cost. The total cost for the case group was found to be more than five times that of the control group (Table 5). The other cost drivers for increased cost in the case group were investigations' charges and hospital room rent. This component is attributed to the increased length of stay.

As anticipated, the mortality in the case group was 28.7% against 3.7% in the control group. This difference was found to be significant. Table 6 represents a comparison of clinical outcomes in the two arms of the study.

Table 2 – Microorganisms causing hospital-acquired infections.

Microorganisms	No. of cases
Acinetobacter. baumannii	45
Escherichia coli	16
Klebsiella pneumoniae	13
Enterococcus faecium	8
Staphylococcus aureus	7
Providencia rettegeri	6
Enterococcus faecalis	6
Pseudomonas aeruginosa	6
MRSA	4
Stenotrophomas maltophilia	3
Staphylococcus auricularis	2
Morganella morgani	2
Others	28

MRSA, Methicillin-resistant *Staphylococcus aureus.*

Discussion

In India, the data on prevalence of HAIs are available [4] but there is no published study analyzing the types of HAIs and the costs associated with them. In this study, an attempt has been made to cover the four major types of HAIs and to assess costs associated with them.

The patients in both the groups were matched for age, diagnosis, and severity of illness to minimize the confounding variables. The patients who have had a road accident and had head injury were more likely to be inserted devices such as urinary catheter, ventilator, or central line. Hence, they were more prone to develop a HAI. Therefore, most of the patients with HAI had diagnosis related to neurosurgery, head injury, or head trauma. This is in agreement with other results reported on a larger sample from multispecialty hospitals [9,10]. The next most common diagnosis was renal failure; patients with renal failure frequently undergo dialysis, and the immunity level is reported to be low [11]. The next two common diagnoses were the diseases of respiratory and vascular systems.

The most common type of HAI was BSIs. An earlier study has also confirmed the fact that having central line–associated BSI is the most common HAI followed by VAP and UTI [12]. These results were in contrast with reports of the other two studies indicating UTI as the most incident HAI [13,14]. The median interval between admission of the patient to the hospital and the development of HAI was 11 days, a finding that was consistent with the results of Mitt et al.' study [15] in which HAIs were shown to have occurred after 13 days.

E. coli and *A. baumannii* were the most commonly found microorganisms in the hospital leading to HAI followed by *Klebsiella pneumoniae* (Table 2). In a retrospective analysis of patients in a Chinese intensive care unit over a 5-year period, Ding et al. [16] reported that *A. baumannii* and *K. pneumoniae* were the most common pathogens [16]. Imipenem was the most frequently prescribed antimicrobial agent because of the higher prevalence of resistant bacteria such as *A. baumannii* (Table 3).

VAP contributed the highest total cost followed by BSI, UTI, and SSI. It is because the charges for ventilator were also included in VAP patients' total cost. The cost of drugs was highest in cases of BSI followed by VAP, UTI, and SSI (Table 4). The percentage of antimicrobials used was the highest for BSI followed by VAP and UTI.

The cost for drugs' acquisition contributed little more than one third of the extra cost (38%). For treating HAIs, mostly imipenem—which is an expensive antimicrobial—was prescribed. Therefore,

Table 3 – Antimicrobial drugs prescribed.

Case group		Control group	
Antimicrobial(s) prescribed	**No.**	**Antimicrobial(s) prescribed**	**No.**
Cilastatin + imipenem	79	Ceftriaxone	30
Metronidazole	54	Ciprofloxacin	24
Piperacillin + tazobactam, linezolid	46	Piperacillin + tazobactam	23
Meropenem, tigecycline	45	Metronidazole, amikacin	22
Levofloxacin	40	Aomxicilin + clavulanic acid	20
Vancomycin, ceftriaxone, teicoplanin, amikacin	37	Cilastatin + imipenem	17
Ciprofloxacin	36	Vancomycin	12
Polymyxin B	31	Levofloxacin, cefuroxime	11
Amoxicilin + clavulanic acid	27	Cefoperazone	10
Clindamycin	25	Azithromycin	9
Colistin	24	Ofloxacin	8
Cefepime	19	Meropenem	6
Cefuroxime	10	Others	29
Tobramycin, ceftazidine	11		
Clarithromycin, pazufloxacin,	9		
Cefoperazone, azithromycin, ampicillin	7		
Aztreonam, prulifloxacin, ertapenem	5		
Others	16		

Note. Arranged in the decreasing order of instances of use.

Table 4 – Different types of average costs associated with four HAIs.

Component of cost, mean ± SEM	Average cost, INR (US $)	VAP, INR (US $)	BSI, INR (US $)	UTI, INR (US $)	SSI, INR (US $)
Total cost	704,175 ± 57,804 (12,803 ± 1,051)	756,895 ± 107,277 (13,762 ± 1,950)	691,334 ± 90,302 (12,570 ± 1,642)	686,457± 122,035 (12,481± 2,219)	533,738 ± 68,044 (9,704 ± 1,237)
Drugs' acquisition costs	266,764 ± 30,063 (4,850 ± 547)	272,342 ± 39,562 (4,952 ± 719)	294,940 ± 57,877 (5,362 ± 1,052)	257,646 ± 60,372 (4,684 ± 1,098)	1654,00 ± 49,234 (3,007 ± 895)
Rent, mean ± SEM	131,718 ± 13,977 (2,395 ± 254)	137,196 ± 30,572 (2,494 ± 556)	110,274 ± 18,186 (2,005 ± 1,051)	13,8601 ± 27,899 (2,520 ± 507)	106,003 ± 39,723 (1,927 ± 722)
Consultation fees	27,908 ± 3,325 (507 ± 60)	31,840 ± 7,504 (579 ± 136)	22,946 ± 4,208 (417 ± 76)	31,011 ± 6,496 (566 ± 118)	23,073 ± 11,187 (402 ± 203)
Investigations	88,603 ± 6,602 (1611 ± 120)	96,065 ± 13,001 (1747 ± 236)	89,859 ± 9,489 (1,634 ± 172)	117,654 ± 13,997 (2,139 ± 254)	51,413 ± 6,655 (935 ± 121)
Antimicrobial drugs	129,400 ± 10,543 (2353 ± 192)	132,950 ± 15,440 (2,417 ± 281)	141,872 ± 19,974 (2,580 ± 363)	113,846 ± 19,638 (2070 ± 357)	124,408 ± 51,767 (2,262 ± 941)
Percentage of AMDs	49	49	48	45	75

Note. US $1 = INR 55.
AMD, antimicrobial drug; BSI, bloodstream infection; HAIs, hospital-acquired infections; INR, Indian rupee; SEM, standard error of the mean; SSI, surgical site infection; UTI, urinary tract infection; VAP, ventilator associated pneumonia.

Table 5 – Hospital treatment costs by different categories.

Different types of costs, mean ± SEM	Cases (n = 108)	Controls (n = 108)	P
Total cost	704,175 ± 57,804 (12,803 ± 1,051)	144,106 ± 15,614 (2,620 ± 284)	<0.001
Drugs' acquisition costs	266,764 ± 30,063 (4,850 ± 547)	29,482 ± 5,156 (536 ± 94)	<0.001
Rent	131,718 ±13,977 (2,395 ± 254)	36,419 ± 4,572 (662 ± 83)	<0.001
Consultation fees	27,908 ± 3,325 (507 ± 60)	7,451 ± 1,033 (135 ± 19)	<0.001
Investigations costs	88,603 ± 6,602 (1611 ± 120)	19,178 ± 1,959 (349 ± 36)	<0.001
Antimicrobials costs	129,400 ± 10,543 (2,353 ±192)	12,047 ± 2,233 (219 ± 41)	<0.001
% of AMDs	49	41	<0.001
% of AMDs (median)	66	28	<0.001

Note. US $ = INR 55.
AMDs, antimicrobial drugs; SEM, standard error of the mean.

Table 6 – Clinical outcomes.

Clinical outcomes	Cases (n = 108)	Controls (n = 108)	P
Improved, n (%)	68 (63)	91 (84.3)	<0.001
LAMA, n (%)	9 (8.3)	31 (12)	<0.001
Death, n (%)	31 (28.7)	4 (3.7)	<0.001
UTI	13	0	–
VAP	33	0	–
BSI	36	100	–
SSI	25	0	–
Average LOS (d)	38	9	<0.001
Average ICU LOS (d)	27	5	<0.001
Average APACHE III score	41	40	0.908
Predicted average hospital mortality (APACHE IV) (%)	10	9	0.315
Predicted average ICU LOS days (APACHE IV)	5	4	0.141

APACHE, Acute Physiology and Chronic Health Evaluation; BSI, bloodstream infection; HAIs, hospital-acquired infections; ICU, intensive care unit; LAMA, left against medical advice; LOS, length of stay; SSI, surgical site infection; UTI, urinary tract infection; VAP, ventilator-associated pneumonia.

almost half of the total drugs' acquisition cost was contributed by AMDs. This finding is in concurrence with previous results [17,18].

Conclusions

HAIs occurred more commonly in patients with head injury and renal failure. The most commonly occurring type of HAI was BSI, and the incidence rate was higher for VAP. The most common pathogens causing HAIs were *A. baumannii* and *E. coli*. The most commonly prescribed AMDs for HAIs was imipenem, while for the matched patients, ceftriaxone and ciprofloxacin were commonly prescribed drugs.

As anticipated, the cost was higher for the hospital as well as for patients due to HAIs. Drugs' acquisition cost formed a major part of the extra cost due to HAIs. In the drugs' acquisition cost, almost half of the share was for AMDs. The usage of AMDs was higher in infected patients than in patients in the control group (49% vs. 41%). VAP ranked first with respect to the economic burden.

This study shows that the cost of drugs is a major contributor to the costs of HAIs as evidenced by five times higher costs in cases than in controls. In view of this, it is recommended that hospitals should take infection control as a high-priority area. This can be achieved by the use of appropriate prophylaxis at admission especially in "high-risk" and immunocompromised patients, use of aseptic techniques, and complete sterilization of surgical instruments before and during the surgical procedures.

Limitations

This study was performed by using data from 216 patients, divided into two equal arms. The patients were not matched for sex and comorbidities. Only the costs based on the documentation in the patient medical record could be captured. Furthermore, it was not possible to take into account the hospital costs for patients subsequently readmitted for infection-related events beyond the review date. A further limitation of the study is the accuracy and reporting of infections and their management as documented in the medical records of each patient. Finally, it is very well appreciated that the treatment costs would differ from one country to another depending on the health financing systems. In view of these, the present findings only reflect hard evidence on the subject in an Indian hospital setting.

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