Special Communication

Hospital Costs and Mortality Attributed to Nosocomial Bacteremias

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• Hospital patients with nosocomial bacteremia and matched hospital control patients without this infection were used to determine the excess hospital costs and mortality attributed to nosocomial bacteremias. Mortality was 14 times greater in patients with nosocomial bacteremia than in matched members of the control group with the same primary diagnoses. An itemized cost analysis, based on 81 case-control pairs, showed an average excess of approximately $3,600 in direct hospital costs for patients who had nosocomial bacteremias. It is estimated that only 24% of the total excess costs to these hospital patients are preventable. Patients with nosocomial bacteremia had an average hospitalization period that was 14 days longer than the average hospital stay for members of the control group.

(*JAMA* 240:2455-2458, 1978)

SEVERAL attempts have been made in recent years to estimate the cost of hospital infections.[1,2] Estimates have been derived by using the average length of hospitalization of patients with nosocomial infections and subtracting the length of the average hospital stay for all hospital patients. The difference in mean hospital stay is then multiplied by the average per diem hospital cost for all hospital patients. This yields an estimate of cost per infection. There are two major problems with these estimates. First, the average hospital stay for all patients does not necessarily reflect a group of patients similar to the infected patients in age, sex, use of hospital services, or underlying diseases. Second, these estimates do not reflect the cost that could be prevented with infection-control measures.

A recent case and matched-control study at the Boston City Hospital showed an additional mean hospital stay of 17 days associated with nosocomial infections.[3] However, to our knowledge, the actual hospital cost differences between similar patients with and without infection and the cost estimates associated with particular types of nosocomial infections have not been reported.

In addition to accurate cost estimates, there is an interest in determining excess mortality attributed to hospital infections, especially nosocomial bacteremias. Several studies have shown that mortality increases with the severity of the infected patients' underlying disease.[4-7] Unfortunately, these studies have not contrasted the hospital outcomes of their cases with the outcomes of a similar group of patients without nosocomial bacteremia.

To determine the excess hospital cost and mortality associated with nosocomial bacteremias, infected patients and individually matched members of the hospital control group were used in this study. In addition, cost reductions that might be expected from preventable infections are presented.

MATERIALS AND METHODS

Nosocomial bacteremia was defined as the presence of bacteria in one or more blood cultures accompanied by a sharp rise in temperature with or without shaking chills in a patient after 48 hours of hospitalization. Patients were excluded if their bacteremia was related to an underlying disease or infection at the time of admission.

Nosocomial bacteremias in hospital patients were identified from infection surveillance files at The Johns Hopkins Hospital. The methods of infection surveillance have been presented previously.[8] The conditions of 435 infected patients were diagnosed between Jan 1, 1972, and Dec 31, 1974. For this study, half of the cases were selected systematically from a list of the 435 patients ordered by year and hospital service.

These cases were then matched with members of a hospital control group selected from hospital computer tapes containing information on all discharged patients. Control subjects were matched individually to infected patients by age group (special newborns, newborn, younger than 1 year, 1 to 3 years, 4 to 6 years, 7 to 9 years, 10 to 14 years, 15 to 19 years, 20 to 29 years, 30 to 39 years, . . ., 80 to 89 years, 90 years or older), race (white, nonwhite), sex, hospital service (17 specialty groups), discharge year, and primary discharge diagnosis (using the International Classification of Disease codes). In addition, the control-group member's length of hospitalization had to be at least as long as the infected patient's hospitalization before the detection of nosocomial bacteremia. After these criteria were satisfied, the member of the control group whose discharge date came closest to the infected patient's discharge date was used as the matched control. Following these selection and matching procedures, 99 matched case-control pairs were identified.

Itemized hospital expenses for each study patient were obtained from hospital summary statements. The microfilmed billing statements could not be found for 18 (9%) of the 198 patients. Therefore, 18 case-control pairs were not used in the itemized cost analysis owing to the lack of billing statements on either the case or the control. Since information on length of stay and hospital outcome was available for these patients, they were included in these aspects of the study.

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Table 1.—Comparison of Characteristics of Billing And Nosocomial Bacteremia Patients*

Factor of Comparison	% of Billing Infected Patients (n=81)	% of Bacteremic Patients (n=435)
Discharge, yr		
1972	30.9	31.3
1973	34.6	34.9
1974	34.5	33.8
Discharge status		
Alive	70.4	65.9
Dead	29.6	34.0
Race/sex		
White man	34.6	35.6
White woman	32.1	32.6
Nonwhite man	16.0	19.1
Nonwhite woman	17.3	12.6
Age, yr		
<1	6.2	6.2
1-19	4.9	8.5
20-39	11.1	14.0
40-59	48.1	32.9
60-79	27.2	31.7
≥80	2.5	6.7
Service grouping		
Surgery	40.7	48.3
Medicine	40.7	32.9
Obstetrics-Gynecology	11.1	8.9
Pediatrics	7.4	9.8

*The Johns Hopkins Hospital, 1972-1974.

Table 2.—Distribution of Patient's Condition on Discharge for the 99 Case-Control Matched Pairs*

	Case Condition	Control Condition	No. of Pairs
a	Dead	Dead	2 (1)†
b	Dead	Alive	28 (22)†
c	Alive	Dead	2 (1)†
d	Alive	Alive	67 (57)†

*McNemar's test[9] determined by $(|b-c|-1)^2/b+c$; $\chi^2=20.8$ with 1 *df* ($P<.001$).

†Number of pairs used in cost analysis for which complete billing information was available.

Table 3.—Mean Differences in Hospital Costs Within Case-Control Pairs*

	Hospital Costs, $		
	Condition on Discharge		
Item	Case Alive Control Alive (n=57)	Case Dead Control Alive (n=22)	Combined† Pairs (n=81)
Total room costs	1,155.47‡	1,430.36	1,153.78‡
Intensive care	15.68	622.73	181.41
Emergency room	−0.14	−2.32	−0.73
Anesthesia	16.40	−1.36	6.67
Operating room	67.81	112.95	71.79§
Medical/surgical supplies	74.98	502.14	187.64§
Recovery room	3.16	1.36	1.36
Intravenous solutions	145.37‡	487.18§	225.89‡
Pharmacy	436.75‡	344.45	382.07‡
Roentgenograms	129.07	283.41§	167.33‡
ECG	13.11	−2.95	8.91
EEG	−3.86	50.00	10.86
Total laboratory charges	743.81‡	1,221.54§	859.12‡
Bacteriology	186.39‡	186.95§	182.14‡
Chemistry	272.46‡	539.27	341.49‡
Hematology	140.44‡	143.45§	141.84‡
Serology	7.21	2.64	6.32
Histopathology	−0.88	−7.91	−5.67
Cytopathology	−3.35	0.41	−2.25
Neurometric	0.00	24.09	6.79
Radioisotope	17.11	−2.14	8.15
Blood charges	337.75‡	672.82§	412.90‡
Physical therapy	12.95	0.64	8.99
Oxygen therapy	115.42§	322.41	170.01§
Total hospital cost	**3,064.39‡**	**5,808.95§**	**3,606.77‡**

*Positive value indicates average excess cost per case.
†Includes two pairs in which control died.
‡ ($P<.001$), determined by the paired *t*-test method.[9]
§ ($P<.01$), determined by paired *t*-test method.[9]

Several methods were used in the analysis. In Table 1, χ^2 tests[9(pp391-393)] are used to examine the representativeness of the infected patients used in this study with regard to the 435 patients with nosocomial bacteremia from 1972 to 1974. For the determination of excess mortality among the cases, the McNemar's test[9(pp126-129)] is used on the case-control pairs in Table 2. The cost analysis used the most frequent billing items included in the patient summary statements. The itemized cost analysis, which examines the issue of significant $\bar{D}$ in hospital costs within case-control pairs for each billing item, is performed by using paired *t*-tests[9(pp116-118)] in Table 3. As numerous tests were performed, a more stringent significance level ($P<.01$) was adopted for the reporting of statistical significance to avoid the chance of false-positive findings.

RESULTS

By selecting each infected patient's and matched control-group member's hospital discharge date as close in time as possible, major cost differences within the case-control pairs would most likely be due to the infection and not to changes in hospitalization fees or medical procedures. All the differences in discharge dates between each infected patient and matched member of the control group fell within one year—46% within one month, 64% within three months, and 89% within six months; and 8% of the pairs had the same discharge dates.

As can be seen from Table 1, the 81 cases used in this investigation are not significantly different ($P>.05$) from all the 435 patients with nosocomial bacteremia by their distributions of discharge year, mortality, race, sex, age, or grouped hospital services. These similarities in patient characteristics are necessary to make generalizations on the hospital costs attributed to nosocomial bacteremias.

Excess Mortality

After matching on primary discharge diagnosis and other patient variables, the 99 case-control pairs were evaluated by their respective conditions at the time of discharge. In Table 2, there are 28 pairs (line b) in which the infected patient died while the member of the control group survived, and there are only two pairs (line c) with the reverse patient outcomes. This excess mortality among the cases is highly significant ($P<.001$). The risk ratio (line b/line c ratio) shows that patients with nosocomial bacteremia had a 14-fold greater risk of dying than matched hospital patients without this infection.

Excess Hospital Cost

The mean hospital cost differences within case-control pairs are presented in Table 3. The Table includes the 81 pairs that had complete billing information available. The case-control pairs in which the infected patients died have been separated from those pairs in which the infected patients were alive at discharge. The purpose was to separate out the patient-cost differential associated with a fatal illness. The results indicate a substantial increase in mean hospital costs incurred by patients with nosocomial bactermia.

In the 57 pairs in which both the infected patient and the member of the control group survived, the average itemized hospital costs are significantly greater ($P<.01$) in infected patients than in members of the control group for the following items (Table 3): total room cost, intravenous solutions, pharmacy, total laboratory charges, bacteriology, chemistry, hematology, blood charges (blood laboratory, blood bank, and administration fees), oxygen therapy, and total hospital cost. Most of these items reflect the excess diagnostic and therapeutic costs associated with nosocomial bacteremia. The other itemized hospital expenses not significantly different were intensive care, emergency room, anesthesia, operating room, medical and surgical supplies, roentgenograms, ECG, EEG, and physical therapy. The lack of difference in these categories may support the similarity between infected patients and members of the control group in their severity of underlying disease. The average total hospital cost excess was $3,064 per case. The average cost of hospitalization was $7,596 for infected patients and $4,531 for members of the control group.

The 22 pairs in which the infected patient died and the member of the control group survived are presented in Table 3. The average itemized hospital costs were significantly greater ($P<.01$) for infected patients than for members of the control group for the following items: intravenous solutions, roentgenograms, total laboratory charges, bacteriology, hematology, blood charges, and total hospital cost. The mean $1,430 excess in total room costs for infected patients was not significantly different because of the large variations in this cost item for both infected patients and members of the control group. There were more similarities in itemized costs for these pairs. The average total hospital cost excess was $5,809 per case. The average cost of hospitalization was $11,338 for infected patients and $5,529 for members of the control group.

From Table 3, the $2,745 difference in total hospital costs between the two types of case-control pairs represents the increased expenses for a fatal illness. The overall hospital costs are higher because there were proportionately more neoplasms among the pairs in which the infected patient died (44%) than in the pairs in which the infected patient survived (21%). Using the 81 case-control pairs from this study, an average total excess of $3,600 can be estimated for patients who had nosocomial bacteremias at The Johns Hopkins Hospital during the study period.

The additional length of hospital stay for patients with nosocomial bacteremia was also reflected in these excess hospital costs. The average excess hospitalization was nine days for infected patients who died. Among these 28 case-control pairs, one infected patient's hospitalization lasted 121 days. Except for this one case, the ranges in hospital stay were five to 76 days for infected patients and seven to 51 days for members of the control group. The average excess hospitalization was 17 days for infected patients who survived. Among these 67 case-control pairs, one infected patient's hospitalization lasted 282 days, and she was not included in the cost analysis for lack of complete billing information. With the exception of this one case, the ranges in hospital stay were six to 89 days for infected patients and four to 69 days for members of the control group. The overall $\bar{D}$ among the 99 case-control pairs was 14 additional days of hospitalization for patients with nosocomial bacteremia.

Preventability of Cost

Based on the average of 145 cases a year and each infected patient having an additional $3,600 hospital cost, the total excess cost for these patients with nosocomial bacteremias would be $522,000 per year during 1972 to 1974. This estimate does not include either the family costs for patient deaths or the value of the patients' productive work time lost by extra hospitalization or death.

It is unreasonable to assume that all of the $522,000 could have been saved through infection-control efforts. Many hospital-acquired infections are inevitable. In a recent study, 59 of 91 cases of bacteremia (65%) would most likely have occurred despite rigid adherence to current infection-control practices.[10] Approximately 40% of all nosocomial bacteremias at The Johns Hopkins Hospital have been attributed to concurrent infections in the patients. Almost all of these concurrent infections are of nosocomial origin as well.[11] A hospital program to reduce the costs related to nosocomial bacteremias would focus on preventing nosocomial infections in general, which indirectly reduces secondary bacteremias, and on improving the aseptic insertion and routine care of intravenous and urinary devices.

In Table 4, a hypothetical reduction of nosocomial bacteremias is presented using estimates on the effectiveness of infection-control practices. An estimated 40% of catheter-related urinary tract infections and an estimated 80% of intravenous catheter-site infections could be prevented by better aseptic insertion and daily care of these indwelling devices. Minimal use of such devices also lowers the risk of infection. Esti-

Table 4.—Hypothetical Reduction of Nosocomial Bacteremias

Verified Source of Bacteremia	% Distributed by Source*	Estimated % Prevented†	% Reduction in Occurrence
Genitourinary	16	40	6.4
Intravenous	13	80	10.4
Respiratory	11	10	1.1
Surgical wound	8	20	1.6
Abdomen	6	5	0.3
Skin	4	10	0.4
Other	4	10	0.4
Unknown	38	10	3.8
Total	**100**	. . .	**24.4**

*Distribution determined from 935 cases of nosocomial bacteremia, The Johns Hopkins Hospital, 1968-1974.[8]

†Estimates based on personal judgments.

mates are made on the preventability of bacterial entry from other sources as well. From these infection-control-program efforts, 24% (or $125,000) of the total excess costs might be preventable. This preventable cost estimate does not consider either the cost of such a control program or the possible reduction in patient costs from the prevention of other types of nosocomial infection.

COMMENT

Our study indicates that excess mortality and hospital costs between infected patients and matched members of the control group over a wide range of diagnoses can be attributed to the occurrence of nosocomial bacteremias. The average 14-day extra hospitalization is lower than other published figures, but this figure relates only to nosocomial bacteremias and is based on a case-control study. Caution must be used when generalizing these findings to other hospital settings. Every hospital has its own patient mixture and method of patient care, both of which influence the cost of hospitalization to a great extent.[12,13]

One potential bias in this study relates to the severity of underlying diseases. Even though infected patients and matched members of the control group had the same primary diagnoses, infected patients might have had more severe complications predisposing them to nosocomial bacteremia and death. Perhaps the excess in hospital cost and mortality among the infected patients may be related to the severity of disease. However, this type of bias seems unlikely when considering the extensive matching and selection processes used in this study. Within case-control pairs who survived hospitalization, there is no evidence of significant differences by intensive care unit costs, emergency room fees, anesthesia fees, operating and recovery room fees, roentgenograms, ECG, EEG, serology, histopathology, cytopathology, radioisotope, or physical therapy costs. These similarities in hospital costs between infected patients and matched members of the control group tend to support the assumption of no major differences in disease severity between infected patients and members of the control group. Another approach to resolve this issue of similarity would be to compare the hospital costs between cases and controls prior to the onset of bacteremia in the case. The costs should be similar. However, the microfilmed billing information that we used was not organized sufficiently for this approach.

The estimates on the preventability of nosocomial bacteremias from several sources were based on personal judgments. Regardless of whether our estimates are too speculative, only a proportion of the total patient costs might be preventable. Whether institutional costs can be reduced is another question left unanswered. There is a dearth of information on the efficacy and cost-effectiveness of infection-control programs.[14] Without such information, only estimates can be used. Since 1976 the Center for Disease Control in Atlanta has been conducting a Study on the Efficacy of Nosocomial Infection Control (SENIC) that will identify the hospital infection-control approaches that have been most effective.[15]

The purpose of this study was to arrive at a realistic patient-cost estimate for nosocomial bacteremias at The Johns Hospkins Hospital for the period 1972 to 1974. Estimates of cost for nosocomial infections will be useful in determining patient or hospital cost reductions if hospital infections are reduced through well-defined infection-control programs. In addition to the SENIC program, carefully designed and conducted studies are needed to determine which infection-control efforts are most effective in reducing infections and hospital expenses.

The Medical Records Department and the Billing Office, The Johns Hopkins Hospital, provided the patient information. Stanley H. Shapiro, PhD, provided statistical review of this manuscript.

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