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Original Article

Microbiology Of Nosocomial Infection In Tertiary Hospitals Of Dhaka City And Its Impact

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Abstract

Nosocomial infection is an endemic problem encountered in hospitalized patients all over the world including Bangladesh. The present prospective study was carried out on 152 patients who were admitted in Dhaka Medical College Hospital and BIRDEM Hospital over a two years period to determine the organisms responsible for nosocomial infection, their antibiotic susceptibility pattern, sources and the impact of hospital infection on patient management.

Samples were collected from postoperative wounds, post catheterized urinary tract infection (UTI) and diabetic wounds. The patients without postoperative wound infection were taken as control group. To trace the sources of infection the samples from the different objects of the hospital environment were studied. The collected samples were cultured and isolated organisms were identified by colony morphology, gram staining and necessary biochemical tests. The identified organisms were tested for antibiogram pattern and plasmid profile.

The predominating organisms responsible for nosocomial infection were *Esch.coli* (55.9%). The other organisms were *Pseudomonas* sp. (33.3%), *Proteus* sp. (12.7%), *Staphylococcus aureus* (5.9%), *Klebsiella* sp. (4.9%) and *Acinatobacter* sp. (3.9%). The isolated organism showed high level of resistance to commonly used antibiotics. The resistance of the organisms markedly increased with the hospital stay. The hospital stay of the infected cases was significantly ($p<0.01$) longer compared to non-infected cases. The cases which had infection with multiple organisms had longer hospital stay than that of cases infected with single organism. No clear association was observed between organisms isolated from hospital environment and infected cases. The study revealed the microbiology of hospital acquired infection in tertiary hospitals and its influence on patient management.

Introduction

Nosocomial infection (NI) is an emerging problem in hospital practice. The rate of NI varies from 9.2% to 21.4% in different countries of the world[1]. The rate of NI has been reported as 11.7% in Thailand, 17.0% in Ethiopia, 9.2% in UK and 9.0% in Norway. However, a few studies have been conducted in Bangladesh. A cross sectional study conducted in 1991 in the surgical wards of Dhaka Medical College Hospital showed that out of 240 patients, 72(38.0%) suffered from NI of which 36.1% had wound infection and 23.6% had UTI[2]. Prevalence of NI in post-operative patients was found to be higher (49.0%) than pre-operative patients (15.9%).

Both Gram positive and Gram negative organisms play an important role in nosocomial infection. In bacterial analysis of hospital acquired infection, Ashraf *et al.*(1973) found that the predominant causative organisms for the post operative wounds were *Esch. coli* (37.5%), *Staph. aureus* (21.7%), *Pseudomonas* sp. (15.1%), *Streptococcus* sp (8.4%), *Proteus* sp. (2.7%) in the surgery wards of Dhaka Medical College Hospital[3]. Another study in 1992 involving eight medical college hospitals of Bangladesh, reported that the commonest organisms were *Esch. coli* (60%) followed by *Staph. aureus* (20%) in postoperative wound infections[4]. A study in a tertiary referral hospital in Dhaka revealed *Staph. aureus* (42.0%) as the most frequently encountered pathogens among the non-

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hospitalized diabetic patients with wound infection while Gram negative organisms like *Pseudomonas* sp. (36.9%), *Esch coli* (21.9%), *Proteus* sp. (21.6%). *Klebsiella* sp. (9.5%) were most common in hospitalized diabetic patients[5]. Similar predominance of Gram negative organisms was found in hospital acquired UTI in other places[6].

Antibiotic sensitivity pattern of organisms causing NI were generally resistant to first generation cephalosporins and beta-lactam antibiotics. Ahmed (1982) observed that there was a definite fall in the sensitivity of *Esch. coli* and *Klebsiella* sp. to ampicillin[7]. In USA, an increase in resistance to ciprofloxacin was observed among nosocomial pathogens especially *Pseudomonas* sp and *Staph. aureus*[8]. The increased resistance rate in organisms isolated from hospitalized patients was due to frequent use of antibiotics in hospitalized patients.

Therefore, the present study is an attempt to investigate the impact of nosocomial infection on hospital stay, the change of antibiotic sensitivity pattern of organisms in relation to the duration of stay in hospital and the possible source of infection in two tertiary care hospitals of Dhaka city.

Materials and Methods

Study population and sample collection

The clinical specimens for this study were collected from the selective patients admitted in Dhaka Medical College Hospital (DMCH) and Bangladesh Institute of Rehabilitation for Diabetes, Endocrine and Metabolic disorders (BIRDEM), Dhaka over a period of two years. Four categories of hospital admitted patients of different age and sex were included in this study namely:

a) Patients with post operative infections: Postoperative patients who developed pus or purulent discharge from operative wounds were selected for sample collection. The sample was collected from the operative wound area by sterile cotton swab on the first day of dressing (in between 5th to 8th postoperative day). A second sample was collected from the same wound 5 to 7 days after the first sample collection if the patients were available.

b) Patients with post catheterized urinary tract infections (UTI): Urine samples were collected aseptically from the patients who were catheterized after admission. 1st sample was collected immediately after catheterization and 2nd sample was collected at least 3 days after catheterization. Culture was done for both the samples. The cases which showed significant growth of bacteria in the 1st sample were excluded from the study. The cases which showed either insignificant or no growth in 1st sample but yielded significant growth in subsequent 2nd sample were included in the study.

c) Newly admitted diabetic patients with wound: Newly admitted diabetic patients with pre existing diabetic wound were considered as study population. 1st sample was collected under aseptic condition from the diabetic wound immediately after admission with a sterile cotton swab stick. A second sample was collected from the same wound 5 to 7 days after the collection of the 1st sample.

d) Post operative patients without wound infection: This group of postoperative patients manifested healed wounds. The non-infected group was included in this study to compare the impact of nosocomial infections in terms of hospital stay with postoperative infected patients.

Sampling of environment and hospital personnel

For detection of the sources of infection samples were collected from the different objects of hospital environment like dressing materials, OT table, floor of OT and wards, bedsheets, instruments of operation theatre as described elsewhere[9,10]. Air sampling from operation theatre and wards was also done by settling plated technique. One blood agar and one MacConkey agar plate were exposed for 30 minutes in the operation theatre during operation and in the ward during dressing of the wound of the patients. The plates were then brought immediately for incubation.

Samples were also collected from nasal cavity, nail folds, inter digital spaces and palms of ward and OT personnel (Doctors, Nurses and ward boys).

Microbiological methods

The organisms were isolated from the specimen by inoculation and subculture on blood agar and MacConkey agar media. Identification of the organisms was done by colony morphology, Gram staining and standard biochemical tests.

All the isolates were tested for sensitivity against antimicrobial agents like ampicilin (AM), co-trimoxazole (TS), cephalexin (CFX), tetracycline (T), ceftriaxone (CRO), ceftazidime (CAZ), ciprofloxacin (CIP), gentamicin (GM) by disc diffusing method of Kirby Bauer *et al.*[11]. The potency of each batch of disc was standardized by the reference strain of ATCC *Esch. coli,* No 25922 and *Pseudomonas aeruginosa* No 27853. Zone of inhibition were compared with the standard value and was considered as sensitive (S), moderately sensitive (M) and resistant (R) according to the NCCLS (1998)[12].

Preservation of organisms

All the isolates were preserved in 15% glycerol broth and stored at -20^0 C for plasmid profile analysis.

Extraction and analysis of plasmid DNA

Plasmid profile analysis (PPA) was done to determine the possible sources of nosocomial infections. The plasmid was

extracted from *Esch. coli, Pseudomonas* sp. and *Klebsiella* sp. which were isolated from the patients and from the hospital environment by Miniprep method[13]. The extracted plasmid DNA was then analyzed by agarose gel electrophoresis. A standard curve was drawn by plotting the mobility of plasmid DNA along the X axis and its molecular weight along the Y axis. The molecular weights of the unknown plasmids were determined from this curve

Data management and analysis

The collected data were checked, verified and edited daily. The data were coded and entered into computer by using SPSS data entry II program. Statistical significance was tested with appropriate tests.

Results

A total of 102 infected cases having different categories of infections and 50 postoperative non-infected cases as control were studied. Out of 102 infected cases, 74(48.7%) had postoperative infection, 16 (10.5%) had post catheterized UTI and the remaining 12 (7.9%) patients had diabetic wound infection (Table I). Among the postoperative cases, laparotomy cases topped the list of performed operation (33.9%), followed by caesarean section (17.7%), appendisectomy (14.15%), inguinal herniorrhaphy 9(7.2%) and wound toileting 7(5.6%). Other operations were fistulectomy 4(3.2%), plastic surgery 3(2.4%), amputation 2(1.6), mastectomy 2(1.6), cystostomy 1(0.8%), sequestrecstomy 1(0.8%), nephrostomy 1(0.8%).

It was observed that out of 42 laparotomy cases, 26(61.9%) had postoperative wound infection. In case of appendisectomy, inguinal herniorrhaphy, cholecystectomy postoperative infected and non-infected cases were 2(11.1%) vs 16(88.9%), 1(11.1%) vs 8(88.9%), 1(14.3%) vs 6(85.7%) respectively.

Table I: Categories study population (n=152)

Categories of cases	Number of Patients	Percentage
Patients with postoperative Surgical wound infection	74	48.7
Patients with post catheterized urinary tract infection+	16	10.5
Patients with diabetic wound infection	12	7.9
Total	102	67.1
Patients without postoperative wound infection	50	32.9
Total	152	100.0

Table-II shows the rate of isolation of organisms from different types of infection. *Each. coli* was the predominating organisms in cases of postoperative wound infection (56.7%) and post catheterized urinary tract infection (68.7%). This was followed by *Pseudomonas* sp. which was 27.0% in case of postoperative wound infection and 18.7% in case of post catheterized UTI while in diabetic wound infection, *Pseudomonas* sp. was the predominating organism (91.7%) followed by *Esch.coli* (33.3%).

Table II: Categories of study population and organisms isolated from different types of infections

Organisms isolated	Post operative wound infection (n=74)		Post catheterized UTI (n=16)		Diabetic wound infection (n=12)		Total (n=102)	
	No	%	No	%	No	%	No	%
Esch.coli	42	56.7	11	68.7	4	33.3	57	55.9
Pseudomonas sp.	20	27.00	3	18.7	11	91.7	34	33.3
Proteus sp.	10	13.5	1	6.2	2	16.7	13	12.7
Staph. aureus	6	8.0	0	00.0	0	00.0	6	5.9
Klebsiella sp.	4	5.4	1	6.2	0	00.0	5	4.9
Acinetobacter sp.	3	4.0	1	6.2	0	00.00	4	3.9

Note: Multiple organisms isolated from one sample; Various species of different organisms isolated were: *Pseudomonas aeruginosa = 30, Paeudomonas flusrescens=2, Pseudomonas cepacia=2, Proteus mirabilis=10, Proteus vulgaris=3, Klebsiella pneumonae=3, Klebsiella oxytoca=1, Acinetobacter* sp=4

Table-III shows the antibiotic resistance pattern of major organisms isolated from the 1st and 2nd samples of different categories infected cases. It was observed that ampicillin was resistant to 100% of *Esch. coli* isolated from the 1st and 2nd sample. It was also observed that susceptibility of *Esch. Coli* to other antibiotics markedly reduced in 2nd samples. There was significant increase ($p<0.01$) of resistance to ceftriaxone (66.6% to 87%), ceftazidime (56.1% to 82.2%), ciprofloxacin (77.2% to 100.00) and gentamicin (80.8% to 100%) in 2nd samples. But no significant ($p>0.05$) change of resistance was found between 1st and 2nd samples to ampicillin, cephalexin, tetracycline and cotrimoxazole. Similarly, resistance of *Pseudomonas* sp and *Proteus* sp to all the used antibiotics increased in 2nd samples.

Table III: Resistance pattern of major organisms isolated from the 1st and 2nd samples of the different categories of infected cases

Name of Antibiotics	No of *E. coli* resistant		No. of *Pseudomonas* resistant		No. of *Proteus* resistant	
	1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample
	(n=57)	(n=23)	(n=34)	(n=25)		
Ampicillin	57 (100.0)	23* (100.0)	34 (100.0)	25* (100.0)	11 (84.6)	9* (80.0)
Cephalexin	49 (85.9)	23* (100.0)	33 (94.1)	25* (100.0)	10 (51.5)	8* (60.0)
Ceftriaxone	38 (66.6)	20** (87.0)	22 (47.1)	22* (64.0)	4 (30.8)	6* (60.0)
Ceftazidime	32 (56.1)	20** (82.2)	17 (50.4)	16* (40.0)	3 (15.4)	6* (40.0)
Tetracycline	51 (89.5)	23* (100.0)	31 (85.3)	25* (100.0)	12 (92.3)	10* (100.0)
Contrimoxazole	51 (89.5)	23* (100.0)	31 (88.2)	25* (100.0)	10 (76.9)	8* (70.0)
Ciprofloxacin	44 (77.2)	23** (100.0)	23 (58.8)	23** (92.0)	7 (53.8)	7** (70.0)
Gentamicin	46 (80.8)	23** (100.0)	22 (52.9)	17* (68.0)	5 (15.4)	7* (50.0)

* p>0.05, **p<0.05 compared between 1st and 2nd samples; Figures in parenthesis indicate percentage.

Table-IV and V shows antibiotic resistance pattern of *Esch. coli* and *Pseudomonas* sp isolated from postoperative infected wounds, post catheterised UTI and diabetic wounds. It was found that resistance pattern of *Esch. coli* isolated from different sites of infection were dissimilar. *Esch. coli* isolated from diabetic wound infections showed the highest resistance to cephalexin (100%) followed by ceftriaxone (75%) ciprofloxacin (75%) ceftazidime (50%) and gentamincin (50%). However, *Esch.coli* isolated from postoperative wound infections showed lower rate of resistance to all the used antibiotics. *Pseudomonas* sp. isolated from the post catheterized UTI showed the highest resistance to cephalexin (100%) followed by ceftrioxone (66.7%) and ciprofloxcin (66.7%). The rate of resistance of *Pseudomonas* sp. isolated from the post operative wound infection ranged between 30-85% to various antibiotics.

Table IV : Antibiotic resistance pattern of *Esch. coli* isolated from different sites of infection

Sites of infection	No. of isolates	Antibiotics: Cephalexin	Ceftriaxone	Ceftazidime	Ciprofloxacin	Gentamicin
Post operative wound infection	42	29 (69.0)	14 (33.3)	7 (16.0)	28 (66.7)	24 (57.1)
Post catheterized UTI	11	10 (90.9)	8 (72.7)	7 (63.6)	9 (81.8)	9 (81.8)
Diabetic wound infections	4	4 (100.0)	3 (75.0)	2 (50.0)	3 (75.0)	2 (50.0)

Figures in parenthesis indicate percentage

Table V: Antibiotic resistance pattern of *Pseudomonas* sp. isolated from different sites of infection

Sites of infection	No. of isolates	Antibiotics: Cephalexin	Ceftriaxone	Ceftazidime	Ciprofloxacin	Gentamicin
Post operative wound infection	20	17 (85.0)	6 (30.0)	7 (35.0)	9 (45.0)	8 (40.0)
Post catheterized UTI	3	3 (100.0)	2 (66.7)	1 (33.3)	2 (66.7)	1 (33.3)
Diabetic wound infections	11	10 (90.9)	5 (45.5)	1 (9.1)	7 (63.6)	5 (45.5)

Note: *Pseudomonas* species included all the species isolated as mentioned in table-2.
Figures in parenthesis indicate percentage.

Table VI: Rate of isolation of single and multiple organisms from different types of infection

Types of infections	Single organism		Two organisms		Three organisms		Total cases	
	No.	%	No.	%	No.	%	No.	%
Postoperative wound infections	64	86.5	9	12.2	1	1.3	74	100.0
Post catheterized UTI	15	93.7	1	6.2	0	0.0	16	100.0
Diabetic wound Infections	8	66.7	3	25.0	1	8.3	12	100.00
Total	87	85.3	13	12.7	2	2.0	102	100.0

Table-VI shows the involvement of single and multiple types of organisms on the causation of infection. It was observed that 85.3% infection was caused by single organism, while 12.7% was caused by two types of organisms and only 2.0% of infection was caused by three types of organisms. About 33% diabetic wound infection was due to multiple organisms.

Table VII: Relationship between type of infection and duration of hospital stay

Category of patients	No. of cases	Mean duration of hospital stay (days)
Postoperative wound infection	74	23.9±14.3
Post catheterized UTI	16	19.9±10.1
Diabetic wound infection	12	26.1±9.9
Postoperative non-infected cases (control)	50	9.5±6.1
Infected with Single organism	87	21.8±10.8
Infected with multiple organisms	15	33.5±20.6

Note: Mean duration of hospital stay of all infected cases was 23.5±13.3 days; $p<0.01$, compared between infected and non-infected control, $p>0.05$, compared between infected with single and multiple organisms group

Table-VII shows the duration of hospital stay of infected and non-infected cases. The mean duration of hospital stay of all infected patients was significantly longer (23.5+13.3 days) than that of postoperative non-infected patients (9.5+6.1 days). Also, the mean duration of hospital stay of each category of patients with infection was longer than postoperative non-infected cases. There was no significant differerences between the mean duration of hospital stay of patients infected with multiple organisms compared to that of single organism (33.5+20.6 days vs 21.8+10.8 days).

Table VIII: Relationship between type of infecting organisms and duration of hospital stay

Types of Organisms	No.	Mean duration of stay (days)
Esch. Coli	49	21.2±9.1 [a]
Pseudomonas sp.	21	18.7±8.7 [a]
Mixed organisms*	15	33.5±20.6
Other organisms**	17	27.4±14.1
Non-infected Group	50	9.5±6.1

Note: * Mixed organisms include *Esch. coli. Pseudomonas* sp. *Proteus* sp,
**Other organisms include *S. aureus, Klebsiella* sp., *Acinetobacter* sp.
a= $p<0.05$, compared between infected with respective organism and non-infected control
$p>0.05$, compared between mixed organisms and non-infected control

Table-VIII shows the relationship between type of infecting organisms and duration of hospital stay. The mean duration of hospital stay of patients infected with different types of organisms ranged between 18-33 days compared to non-infected group. Though the longest duration of hospital stay was 33.5+20.6 days for infections caused by mixed organisms (*Esch. coli* + *Pseudomonas sp.*+*Proteus* sp.) the difference was not statistically significant ($p>0.05$) when compared with cases infected with other organisms.

Organisms isolated from hospital environment, various hospital objects and personnel are shown in Table-IX. Various Gram negative and positive organisms were isolated from OT air, table, floor, tap water, distal end of suction tube and ward floor. Nasal cavity, palm, nail bed and inter digital spaces of the OT and ward personnel yielded *Strep. viridans.*

The molecular weight and the number of extracted plasmid DNA of the representative isolates of the patients and the hospital environment was shown in Table-X. The number of plasmid DNA and its corresponding molecular weight were also compared. The pattern of plasmid DNA of the patient and that of the hospital environment was dissimilar.

Table IX: Organisms isolated from different objects in hospital environment

Organisms	Frequency of isolates	Sources
Esch. coli	7	OT air, table, floor, tap water, suction tube, Ward floor
Pseudomonas sp.	2	OT air, boiled water
Klebsiella sp.	2	OT floor
Proteus sp.	1	OT gloves
Strept. Viridans	6	Nasal cavity
Staphylococcus (Coagulase negative	15	OT air, Nasal cavity, plam, nail bed and inter digital spaces of the OT and ward personnel,
B. subtilis	12	OT floor, ward floor and bed shee

Table X: Plasmid profile of the selected organism isolated from patients and hospital environment

Organisms isolated from the patients					Organisms isolated from the hospital environment				
SP No.	Organisms	Source	No.	Plasmid MW (mDa)	SP No.	Organisms	Source	No.	Plasmid Mol. wt. (mDa)
59	Klebsiella sp.	Wound	1	26.7	OT	Klebsiella sp.	OT Floor	3	18.7,8,6.7
63	Esch. coli	Wound	2	28, 16.7	OT	Esch. coli	OT table	4	28,25,3, 16,7,5.3

Discussion

Nosocomial infection is a problem affecting the hospitalized patients both in developed and developing countries. In developed countries many interventions were made to control nosocomial infection. But in developing countries like Bangladesh no emphasis has yet been given in this field. In different situations and perspective the pattern of nosocomial infections is different. In the present study, an attempt was made to explore the pattern of organisms responsible for hospital acquired infection in large hospitals of Dhaka city. The antibiogram pattern of the offending organisms and the probable sources of infection were also investigated. In this study, it was observed that the most common infective organism was *Esch. coli* (55.9%) followed by *Pseudomonas* Sp. (33.3%) and *peroteus* sp. (12.7%). In an earlier study in Bangladesh in 1973, reported similar predominance of Esch. Coli (37.5%) in hospital aquired wound infection[3].

Another study in Bangladesh in 1992, showed that *Esch. coli* was the major pathogen (60.0%) in the postoperative infection followed by *Staph. aureus*[4]. Similar predominance of *Esch. coli* and other Gram negative organisms were reported in hospital acquired infection in Canada[14]. However Aman (1982) in Lahore found that the predominating causative organism of surgical infection was *Staph. aureus* (28.6%) followed by *Esch. coli* (24.7%) and *Pseudomonas* Sp. (23.7%)[15]. The isolation rate of different organisms varied in different clinical samples. In the present study *Esch. coli* was the predominating organisms in post operative infection and UTI, while *Pseudomonas* sp. was the predominating organism in the diabetic wound. Similarly many studies in Bangladesh and other countries showed different isolation rate in different clinical samples. But in diabetic wounds *pseudomonas* sp. was the offending organism (91.7%) followed by *Esch. coli* (33.3%). In Bangladesh, Jinnah *et al.,* (1998) reported that *Pseudomonas* sp. was the major isolate from the patients with diabetic wound infection[5]. However, the isolation rate of *Pseudomonas* sp. was much less (36.9%) as compared to the present study. This difference in rate might be due to small sample size or difference in sample selection procedure. The variation in the isolation of organisms by various workers in the same or in different localities over time might be due to use of different antibiotics and the elimination of susceptible organisms by the antibiotic resistant organisms like *Pseudomonas* sp. and *Proteus*[16].

The high rate of antibiotic resistance of isolated organisms in our study might be due to wide spread use of antibiotics in our hospitals. The antibiogram pattern of the organisms isolated from the first samples was also compared with the second samples collected 5 to 7 days later. It was observed that 100.0% of *Esch. coli* was resistant to ampicillin in both first and second samples. There was significant increase in resistance to ceftriaxone (from 66.6 to 87%, $p>0.01$), ceftazidime (from 56.1 to 82.2%, $p<0.02$), ciprofloxacin (from 77.2 to 100.0%, $p<0.005$) and gentamicin (from 80.8 to 100%, $p<0.008$). In case of *Pseudomonas* sp. and *Proteus* sp. a marked increase in resistance to antibiotics were also observed. Resistance rate highly increased in 2nd samples in case of both the organisms. It was also observed that resistance rate of *S. aureus* was relatively lower than that of Gram negative organisms. This higher resistance in Gram negative organisms might be due to the production of extended spectrum beta-lactamases by Gram negative organisms[17]. Increased level of resistance in hospital isolates was also reported to the commonly used antibiotics by others[4,5,6,8]. We have noted that the resistance of isolated organisms to the prescribed antibiotics ranged from 62-100%. In this study it was observed that single type of organism was the common cause of infection in majority of cases. About 15 % of infection was caused by multiple organisms. In an earlier study, Shaw *et al*., (1973) showed that out of 204 infected cases 86.3% was caused by single organism and the remaining 13.7% was caused by mixed organisms[18]. This higher rate of infection with single organism could be due to difference in site of operation. The duration of the hospital stay was profoundly influenced by the infections. The hospital stay of the infected cases was significantly longer compared to non-infected cases. However, the cases which had infection with more that one or mixed organisms had longer hospital stay than that of cases infected with single organism.

In this study different organisms were isolated from different objects of the hospital environment. It was found that *Esch. coli* was the major isolates from the OT air, table, floor, tap water, suction tube and ward floor. *Pseudomonas* sp. was isolated from OT air and boiled water. *Klebsiella* sp. was isolated from OT floor and *Proteus* sp. was isolated from OT gloves. The isolated organisms from the possible sources showed a wide range of resistance to the antibiotics used in the hospital. An attempt was made to trace the sources of nosocomial infection. In this regards, plasmid profile analysis (PPA) was carried out with the representative organisms isolated from the different objects and hospital staffs with those of wound samples of the study population. It was observed that plasmid profile of the isolates of the probable sources was not of similar to those of wound samples. Though sources of nosocomial infection could not be traced by PPA, it was evident that *Esch.coli*, *Pseudomonas* sp, *Proteus* sp, *Klebsiella* sp. isolated from the different objects of hospital environment might be a potential source of nosocomial infection.

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