



Prevalence and Antimicrobial Resistance Pattern of Gram-Negative Bacteria Isolated from Burn Wound Patients and Burn Unit Environment at Largest Teaching Hospital in Bangladesh

Md. Faizur Rahman¹, Rubaiya Binte Kabir², SK Saiful Alam³, SM Shamsuzzaman⁴

¹Lecturer, Department of Microbiology, Dhaka Medical College, Dhaka, Bangladesh; ²Lecturer, Department of Microbiology, Dhaka Medical College, Dhaka, Bangladesh; ³Associate Professor and Head, Department of Microbiology, Shaheed Tajuddin Ahmed Medical College, Gazipur, Bangladesh; ⁴Professor and Head of Research, Universal Medical College, Dhaka, Bangladesh

Abstract

Background: Gram-negative bacteria are a common cause of infections in burn patients, and a major cause of nosocomial wound infection. **Objective:** The purpose of the present study was to isolate and identify gram-negative bacteria from both burn wounds and the environment of burn wards, and to detect their antimicrobial resistance pattern at Dhaka Medical College Hospital (DMCH). **Methodology:** This cross-sectional study was conducted at the Department of Microbiology, Dhaka Medical College from the period January to December, 2016. Burn swabs were collected from patients admitted in burn unit of DMCH, and environmental samples were collected from various areas of burn unit. Samples were cultured in blood agar and MacConkey's agar media. Organisms were identified by colony morphology and biochemical tests. Antimicrobial susceptibility was done by Kirby Bauer disc diffusion method. ESBL-producing organisms were identified by Double Disc Synergy test. **Results:** Out of 300 burn wounds, 294 (98%) were culture positive. Among 294 (98%) organisms, the most prevalent was *Pseudomonas aeruginosa* (43.19%), followed by *Klebsiella* species (17.68%), *Proteus* species (13.94%), and others. Out of 200 environmental samples, 37 (18.50%) yielded growth in culture. Among them, *Pseudomonas aeruginosa* was (44.82%), followed by *Escherichia coli* (20.68%), *Klebsiella* species and *Acinetobacter* species (13.79%), and *Citrobacter* species (6.89%). Among the isolated gram-negative organisms from burn wound the highest resistance observed were *Pseudomonas aeruginosa* to Ceftazidime (86.61%), *Klebsiella* species to ciprofloxacin (92.30%), *Proteus* species to amikacin (95.12%), *Escherichia coli* to Ciprofloxacin (92.31%) *Enterobacter* species and *Citrobacter* species both to cefuroxime and *Acinetobacter* species to gentamicin (92.3%). All the gram-negative organisms were highly sensitive for colistin except *Klebsiella* species where imipenem was most sensitive. Antibiotic resistance pattern is not statistically significant between *Pseudomonas aeruginosa* isolated from burn wounds and environmental samples. Only isolated gram-positive organism was *Staphylococcus aureus* (1.36%). Among the isolated gram-negative bacteria, 85 (29.31%) and 7 (24.13%) were ESBL producers, isolated from clinical samples and environmental samples, respectively. **Conclusion:** This study provides insight into the emergence of multidrug resistant organisms in both clinical and environmental samples. *Pseudomonas aeruginosa* is the most prevalent organism isolated from clinical samples. The finding also suggested environment as a reservoir of various gram-negative organisms for infections in burn patients.

Keywords: Prevalence; antimicrobial resistance; Gram negative bacteria, burn wound; burn unit environment

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Correspondence: Dr. Md. Faizur Rahman, Lecturer, Department of Microbiology, Dhaka Medical College, Dhaka, Bangladesh; Cell No.: +88-01744960564; Email: nirjharsting@gmail.com; ORCID: <https://orcid.org/0000-0002-0537-8091>
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Introduction

Over the last several decades, gram negative organisms have emerged as the most common etiologic agents of invasive infection by virtue of their large repertoire of virulence factors and antimicrobial resistance traits¹⁻². Burn wound infection is one of the

most important and potentially serious complications that occur in the acute period following injury³. Although burn wound surfaces are sterile immediately following thermal injury, these wounds eventually become colonized with microorganisms including gram positive and gram negative bacteria, derived from the host's normal gastrointestinal and upper respiratory flora or from the hospital environment or that are transferred via a health care worker's hands^{2,4,5}. Among the gram-negative organisms, *Pseudomonas aeruginosa* is the most common source of burn wound infection². When infection by *Pseudomonas aeruginosa* occurs in burn patients, treatment becomes particularly challenging, and the mortality rate reaches up to 40.0% to 50.0% cases⁶. *Pseudomonas aeruginosa* can be transmitted from person to person through life support equipment, cosmetics, diluted antiseptics, and even through washing liquids, and soaps⁷.

Bacterial infections in burn wounds are common and difficult to control. In recent decades, following the introduction of antibiotic therapy, gram-negative organisms are increasingly isolated as a nosocomial pathogen, and are responsible for high morbidity and mortality rates in burn patients⁸. Overcrowding in burn units is an important cause of cross-infection⁹. Exogenous organisms from the hospital environment are generally more resistant to antimicrobial agents than endogenous organisms and act as a source of infection in burn patients¹⁰. Microorganisms routinely isolated from burn wounds include aerobic organisms such as, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella spp*, and *Proteus species*¹¹. Extended-spectrum beta-lactamase (ESBL) producing strains are at rise and notable for their increasing resistance to a broad array of different antimicrobial agents^{12,13}. Despite of the huge significance studies in the effective management of nosocomial infections in burn injuries, there are only a few studies regarding the epidemiology of gram-negative organisms isolated from burn wounds and environment in Bangladesh.

Therefore, this study has been designed to identify bacteria from clinical specimens and the burn unit environment and to determine the resistance pattern of gram-negative organisms isolated from burn wounds and environmental samples of the burn unit of Dhaka Medical College Hospital (DMCH), Dhaka.

Methodology

Study Settings and Population: This cross-sectional

study was conducted in the Department of Microbiology at Dhaka Medical College, Dhaka, Bangladesh, from January to December 2016. A total of 300 wound swabs and 200 environmental samples were collected from Burn and Plastic Surgery department of DMCH regardless of age, sex and antibiotic intake history were included in this study.

Study Procedure: For environmental samples, rubber sheets, beds, floor, walls, bath tanks, air coolers, trolleys, antiseptic solution of different wards of the department, such as high dependency unit (male, female), neonatal high dependency unit, general ward (male, female), paying (male, female), cabin and child ward were selected. Hospitalized patients who did not give consent were excluded from this study. Clinical samples were collected aseptically from patients using sterile cotton-tipped swab stick from the wound site prior to any cleansing. Environmental samples were taken using sterile cotton-tipped swab stick, and before using they were moistened with sterile trypticase soya broth (TSB). Specimens were immediately kept in a sterile test tube, capped properly and labeled. Then the samples were transferred to the microbiology laboratory without delay. Gram stain of all wound swabs was done to confirm infection by observing presence of inflammatory cells.

Bacterial Isolation: All wound and environmental swabs were inoculated in both blood agar and MacConkey's agar media and incubated at 37°C aerobically for 24 hours. Organisms were isolated and identified by observing colony morphology on the blood agar and MacConkey agar media, Gram staining and standard biochemical tests¹⁴.

Antimicrobial Susceptibility Test: Susceptibility to antimicrobial agents of all isolated organisms was tested by Kirby Bauer modified disc diffusion technique using Mueller Hinton agar plates and zones of inhibition were interpreted according to CLSI guidelines 2015^{15,16}. Antibiotic discs such as ceftazidime (30µg), ceftriaxone (30µg), amoxiclav (amoxicillin 20µg & clavulanic acid 10µg), ciprofloxacin (5µg), amikacin (30µg), tigecycline (15µg), imipenem (10µg), cefepime (30µg), gentamycin (10µg), cefuroxime (30µg), piperacillin/tazobactam combination (110µg) were used. Tigecycline susceptibility was determined by 15µg disc following the United States Food and Drug Administration (FDA) criteria for interpretation¹⁷. ESBL producers were detected by double disc synergy test¹⁸. MIC of colistin was done according to CLSI 2015. Data regarding age, sex and antibiotic intake

with duration of hospital stay were collected using a predesigned data collection sheet.

Data Analysis: Data for categorical variables were presented as numbers and percentages. The Pearson Chi-square test was used to define statistical significance. All tests with p value less than 0.05 were considered significant with a 95.0% confidence interval. The data were statistically evaluated with Microsoft Excel 2010.

Ethical Clearance: Informed written consent was taken from patients or their legal guardian. The research protocol was approved by Research Review Committee (RRC) of the Department of Microbiology of Dhaka Medical College (DMC) and ethical clearance was taken from the Ethical Review Committee of DMC (Memo no. MEU-DMC/ECC/2016/230).

Results

In this study, samples were collected from burn wounds and different environmental objects. Out of 300 burn wound swabs, 294(98.0%) were culture positive. Among 294 (98%) isolated bacteria, gram-negative organisms were 290(98.6%), and gram-positive organisms were 4(1.37%). Out of 294(98%) organisms, the most prevalent was *Pseudomonas aeruginosa* in 127(43.2%) followed by *Klebsiella* species in 52(17.7%), *Proteus* species in

41(13.9%), *Escherichia coli* in 26(8.9%), *Citrobacter* species in 14(4.8%), *Enterobacter* species in 13(4.4%), *Acinetobacter* species in 13(4.4%), and gram-positive organism *Staphylococcus aureus* were in 4(1.4%) (Table 1).

Among 200 environmental samples, 37(18.5%) were culture positive. Among isolated bacteria from environmental samples, gram-negative organisms were 29(78.4%), and gram-positive organisms were 8(21.6%). Organisms were isolated from samples collected from rubber sheet, bed, floor, wall, bath tank. No organisms were found from samples collected from air cooler, trolley and antiseptic solution. Out of 37(18.5%) isolated bacteria the most prevalent was *Pseudomonas aeruginosa* (44.8%), followed by *Escherichia coli* (20.7%), *Klebsiella* species, *Acinetobacter* species (13.8%), and *Citrobacter* species (6.9%) (Table 2).

Regarding resistance pattern of *Pseudomonas aeruginosa*, most were resistant to ceftazidime (86.61%), only 11.8% were resistant to colistin and 37.89% were resistant to imipenem. Among the isolated *Klebsiella* species, most were resistant to ceftriaxone (92.30%), followed by 90.38% to amoxiclav and gentamicin. Among the isolated *Proteus* species, most were resistant to amikacin (95.12%), followed by 94% to amoxiclav. *Esch. coli*, were highly resistant to ciprofloxacin (92.31) and least to colistin (3.84%). 80% of *Enterobacter* species, were resistant to cefuroxime and only 7.69% to colistin. Among the isolated *Citrobacter* species, 85.71% were resistant to cefuroxime, and 7.14% to colistin, which is the least. Among the isolated *Acinetobacter* species, 92.30% were resistant to gentamicin. All the isolates were sensitive to colistin (Table 3).

Regarding resistant pattern of *Pseudomonas aeruginosa*, all were sensitive to colistin and most of them were resistant to ceftazidime (86.6%) Among the isolated *Klebsiella* species all were resistant to amoxiclav, and ciprofloxacin. Among isolated

Table 1: Distribution of Bacteria Isolated from Culture Positive Burn Wound Samples (N=294)

Species of bacteria	Frequency	Percent
<i>Pseudomonas aeruginosa</i>	127	43.2
Other <i>Pseudomonas</i> species	4	1.4
<i>Klebsiella</i> species	52	17.7
<i>Proteus</i> species	41	13.9
<i>Esch. coli</i>	26	8.9
<i>Citrobacter</i> species	14	4.8
<i>Enterobacter</i> species	13	4.4
<i>Acinetobacter</i> species	13	4.4
<i>Staphylococcus aureus</i>	4	1.4

Table 2: Distribution of Bacteria Isolated from Culture Positive Environmental Samples (N=37)

Source	<i>P. aeruginosa</i>	<i>S. aureus</i>	<i>Esch. coli</i>	<i>Klebsiella</i> species	<i>Acinetobacter</i> species	<i>Citrobacter</i> species
Rubber sheet	5(38.5%)	3(37.5%)	2(33.3%)	0(0.0%)	2(50.0%)	1(50.0%)
Bed	3(23.1%)	3(37.5%)	4(66.7%)	3(75.0%)	0(0.0%)	0(0.0%)
Floor	3(23.1%)	1(12.5%)	0(0.0%)	0(0.0%)	1(25.0%)	1(50.0%)
Wall	2(15.4%)	1(12.5%)	0(0.0%)	1(25.0%)	0(0.0%)	0(0.0%)
Bath tank	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(25.0%)	0(0.0%)
Total	13(44.8%)	8(27.6%)	6(20.7%)	4(13.8%)	4 (13.8%)	2(6.9%)

P. aeruginosa=*Pseudomonas aeruginosa*; *E. coli* =*Escherichia coli*; *S. aureus*=*Staphylococcus aureus*

Table 3: Antimicrobial Resistance Pattern of Gram-Negative Organisms Isolated from Wound Sample

Antimicrobial drugs	<i>Pseudomonas aeruginosa</i> (N=127)	<i>Klebsiella</i> spp. (N=52)	<i>Proteus</i> spp. (N=41)	<i>E. coli</i> (N=26)	<i>Citrobacter</i> spp. (N=14)	<i>Acinetobacter</i> spp. (N=13)
IPM	48(37.9%)	14(26.9%)	10(24.4%)	8(30.8%)	9(64.3%)	5(38.5%)
CT	15(11.8%)	16(30.8%)	-	1(3.8%)	1(7.1%)	0(0.0%)
TZP	72(56.7%)	37(71.2%)	12(29.1%)	16(61.5%)	3(21.4%)	11(84.6%)
TGC	-	33(63.5%)	-	2(7.7%)	8(57.1%)	3(23.1%)
CRO	-	48(92.3%)	32(78.0%)	22(84.6%)	10(71.0%)	11(84.6%)
CAZ	110(86.6%)	46(88.4%)	34(82.9%)	18(69.2%)	9(64.3%)	11(84.6%)
FEP	109(85.8%)	45(86.5%)	33(80.5%)	16(61.5%)	5(35.7%)	9(69.2%)
AMC	-	47(90.4%)	38(94.0%)	22(84.6%)	9(64.3%)	-
AK	103(81.10)	45(86.5%)	39(95.1%)	16(61.5%)	5(35.7%)	8(61.5%)
CN	101(79.5)	47(90.4%)	30(73.2%)	19(73.1%)	5(35.7%)	12(92.3%)
CIP	101(79.5)	37(71.2%)	33(80.5%)	24(92.3%)	9(64.3%)	9(69.2%)
CXM	--	40(76.9%)	-	19(73.1%)	12(85.7%)	11(84.6%)

IPM= imipenem, CT= Colistin, TZP= Piperacilline- Tazobactam, TGC= Tigecycline, CRO= Ceftriaxone, CAZ= Ceftazidime, FEP= Cefepime, AMC= Amoxiclav, AK= Amikacin, CN= Gentamicin, CIP= Ciprofloxacin, CXM= Cefuroxime

Table 4: Antimicrobial Resistance Pattern of Gram-Negative Organisms Isolated from Environmental Samples

Antimicrobial drugs	<i>Pseudomonas aeruginosa</i> (N=13)	<i>Klebsiella</i> spp. (N=4)	<i>E. coli</i> (N=6)	<i>Citrobacter</i> spp. (N=2)	<i>Acinetobacter</i> spp. (N=4)
IPM	4(30.8%)	1(25.0%)	2(33.3%)	2(100.0%)	1(25.0%)
CT	0(0.0%)	0(0.0%)	2(33.3%)	0(0.0%)	0(0.0%)
TZP	6(46.2%)	2(50.0%)	4(66.7%)	0(0.0%)	3(75.0%)
TGC	-	1(25.0%)	4(66.7%)	1(50.0%)	1(25.0%)
CRO	-	3(75.0%)	5(83.3%)	2(100.0%)	4(100.0%)
CAZ	11(84.6%)	3(75.0%)	5(83.3%)	2(100.0%)	4(100.0%)
FEP	11(84.6%)	3(75.0%)	4(66.7%)	2(100.0%)	3(75.0%)
AMC	-	4(100.0%)	5(83.3%)	2(100.0%)	-
AK	10(76.9%)	3(75.0%)	5(83.3%)	1(50.0%)	3(75.0%)
CN	9(69.2%)	3(75.0%)	5(83.3%)	2(100.0%)	4(100.0%)
CIP	10(76.9%)	4(100.0%)	5(83.3%)	2(100.0%)	3(75.0%)
CXM	-	3(75.0%)	4(66.7%)	1(50.0%)	4(100.0%)

IPM= imipenem, CT= Colistin, TZP= Piperacilline- Tazobactam, TGC= Tigecycline, CRO= Ceftriaxone, CAZ= Ceftazidime, FEP= Cefepime, AMC= Amoxiclav, AK= Amikacin, CN= Gentamicin, CIP= Ciprofloxacin, CXM= Cefuroxime

Escherichia coli, 83.3% were resistant to ceftriaxone, ceftazidime, amikacin, gentamicin, ciprofloxacin, and amoxiclav. Among the isolated *Citrobacter* species, all were resistant to most of the antibiotics except 50.0% resistant to tigecycline and amikacin. All of them were sensitive to colistin and piperacilline-tazobactam. Among the isolated *Acinetobacter* species, all were resistant to ceftriaxone, gentamicin, cefuroxime, and ceftazidime. Most of the organism showed highest sensitivity to colistin (Table 4).

Antibiotic resistance pattern is not statistically significant between *Pseudomonas aeruginosa* isolated from burn wounds and environmental samples (Table 5).

Out of 290 isolated gram-negative bacteria from infected burn wounds, 85 (29.31%) were ESBL producers detected by double disc synergy (DDS) test.

Table 5: Comparison of Antimicrobial Resistance Pattern between *Pseudomonas aeruginosa* Isolated from Burn Wounds and Environmental Samples

Antimicrobial Drugs	<i>Pseudomonas aeruginosa</i>		P value
	Burn wound (N=127)	Environmental (N=13)	
IPM	48(37.9%)	4(30.8%)	0.10
CT	15(11.8%)	0(0.0%)	
TZP	72(56.7%)	6(46.2%)	
CAZ	110(86.6%)	11(84.6%)	
FEP	109(85.8%)	11(84.6%)	
AK	103(81.1%)	10(76.9%)	
CN	101(79.5%)	9(69.2%)	
CIP	101(79.5%)	10(76.9%)	

N= Number of bacteria, n= number of resistant bacteria; IPM= imipenem, CT= Colistin, TZP= Piperacilline-Tazobactam, TGC= Tigecycline, CRO= Ceftriaxone, CAZ= Ceftazidime, FEP= Cefepime, AMC= Amoxiclav, AK= Amikacin, CN= Gentamicin, CIP= Ciprofloxacin.

Table 6: Distribution of ESBL Producing Bacteria Isolated from Burn Wounds and Environmental Samples Identified by Double Disc Synergy Test (DDS) test

Bacteria isolated from wound swab	ESBL Producing Strains	Bacteria Isolated from Environment	ESBL Producing Strains
<i>P. aeruginosa</i> (N=127)	33(26.0%)	<i>P. aeruginosa</i> (N=13)	3 (23.1%)
<i>Klebsiella</i> species (N=52)	22 (42.3%)	<i>Klebsiella</i> species (N=4)	2 (50.0%)
<i>Proteus</i> species (N=41)	13 (31.7%)	<i>Escherichia coli</i> (N=6)	2 (33.3%)
<i>Escherichia coli</i> (N=26)	11 (42.3%)	<i>Acinetobacter</i> species (N=4)	0(0.0%)
<i>Enterobacter</i> species (N=13)	3 (23.1%)	<i>Citrobacter</i> species (N=2)	0(0.0%)
<i>Citrobacter</i> species (N=14)	3 (21.42%)	-	-
Total	85 (29.3%)	Total	07 (24.1%)

P. aeruginosa=*Pseudomonas aeruginosa*; *E. coli* =*Escherichia coli*

Out of all, 25.98% *Pseudomonas aeruginosa*, 42.3% *Klebsiella* species, 31.7% *Proteus* species, 42.3% *Escherichia coli*, 23.07% *Enterobacter* and 21.4% *Citrobacter* species were ESBL producer. Alongside out of 29 isolated gram-negative bacteria from environmental samples, 7 (24.13%) were ESBL producers detected by double disc synergy test (DDS) test. Out of them, 23.07% *Pseudomonas aeruginosa*, 50% *Klebsiella* species and 33.33% *Escherichia coli* were ESBL producer (Table 6).

Discussion

In the present study, out of 300 burn wound swabs, 98.0% were culture positive. Abedin¹⁹ reported and Farzana et al²⁰ reported similar results in DMCH, Bangladesh. High rate of burn wound infection might be due to the fact that more invasive diagnostic and therapeutic procedures and prolong stay in hospital. Reason higher prevalence might be due to the fact that different infection control policies in different hospitals and overcrowding of burn patients in Bangladesh. In contrast to this study Alwan et al²¹ reported that 64.3% burn wound swabs were culture positive in Baghdad, which do not coincide with the present study.

Incidence of infection varies from place to place and country to country due to different therapeutic and preventive policy²². A study carried out by Saha et al²³ in DMCH on burn patients found *Pseudomonas aeruginosa* as the highest isolated organism (39.0%), Farzana et al²⁰ found *Pseudomonas aeruginosa* as the highest (45.0%) isolated organism and *Klebsiella* species (21.7%) second common isolated organism, Abedin¹⁹ also found *Pseudomonas aeruginosa* as the highest (43.9%) isolated organism and *Klebsiella* species (20.7%) second highest isolated organism. All of the various studies showed similar prevalence of isolated organisms like present study. A study by Mundhada et al²⁴ in India showed that the most

common organism isolated from burn wounds was *Klebsiella pneumoniae* (34.4%) which does not correlate with this study.

Saha et al²³ reported that 77.5% of environmental samples were culture positive, Ndip et al²⁵ reported that 28.0% environmental samples were culture positive. These studies are not similar to present study. Reason behind the difference might be due to the fact that isolation rate of organisms varies with time as well as from country to country and even hospital to hospital of same city²⁰. Gamal et al²⁶ found 19.5% *Pseudomonas aeruginosa* and these were isolated from hospital environmental samples in Egypt, which is lower than the present study. Reason of lower isolation rate showed by Gamal et al²⁶ might be due to samples were taken from hospital environments not from burn unit and organisms are naturally more in number due to overcrowding of burn wards²⁶. Saha et al²³ showed that 22.5% *Pseudomonas aeruginosa* were isolated from environmental samples of burn unit in DMCH, which is lower than the present study. Higher proportion of *Pseudomonas aeruginosa* in the present study might be due to time related change.

In DMCH, Farzana et al²⁰ reported 35.7% and Abedin¹⁹ reported 36.8% imipenem resistant *Pseudomonas aeruginosa* isolated from burn wounds which are similar to this study. In contrast higher proportion (69.0%) of imipenem resistant *Pseudomonas aeruginosa* from burn wounds were reported by Sadari et al²⁷ from Iran. A study in a tertiary care hospital in Thailand reported that 44.4% imipenem resistance among *Pseudomonas aeruginosa*²⁸. This increased trend of resistance may be due to selective pressure as a result of increased use and increased carbapenemase production along with intrinsic resistance by *Pseudomonas aeruginosa*.²⁹

Similar results regarding resistance to colistin were reported by Farzana et al²⁰ (13.3%) and Abedin¹⁹ (8.1%). Biswal et al³⁰ reported that none of the

Pseudomonas aeruginosa were resistant to colistin in India which is lower than this study. This higher rate of colistin resistance in Bangladesh might be due to the fact that increased use of colistin as a last resort of treatment, creating selective pressure leading to increased resistance but still now this is a good alternative drug as reported that by Khatun³¹ from DMCH, Bangladesh. For multidrug resistant isolates, antibiotic choice may be quite limited. The most effective agents in vitro are polymyxins (colistin)³²⁻³³.

In contrast to present study Affifi et al³⁴ reported that 11.9% *Pseudomonas aeruginosa* from environmental samples were resistant to gentamycin, 9.5% to ceftazidime which do not coincide with this study. They also collected samples from hospital environment and in this study, samples were taken from burn unit³⁴. Burn wounds are usually extensive and difficult to take proper care, so cross contamination occurs, and drug-resistant organisms are naturally higher in burn wards.

Present study observed the comparison of antibiotic resistance pattern between *Pseudomonas aeruginosa* isolated from burn wounds and environmental samples which revealed that antibiotic resistance patterns were not significantly different. A study by Affifi et al³⁴ also reported that antibiotic resistance patterns were same in *Pseudomonas aeruginosa* isolated from burn wounds and environmental samples. Jaafari et al³⁵ also reported that antibiotic resistance pattern between *Pseudomonas aeruginosa* isolated from burn wounds and from environmental samples were almost same. The present study suggests that *Pseudomonas aeruginosa* isolated from burn wounds and from environment of burn unit of DMCH have the same antibiotic resistance pattern.

A study by Abedin¹⁹ showed that 32.8% of isolated gram-negative bacteria were ESBL producers which is similar to this study. The prevalence of ESBL producers is increasing in Bangladesh according to many studies in DMCH in the recent past. In 2008, ESBL producers were 26.9% followed by 31.0% in 2013 and 38.2% in 2014^{31,36,37}. The drop in ESBL producers in this study might be due to the fact that, the use of penicillin, ampicillin, amoxicillin and cephalosporin have been decreased significantly in the past few years due to development of resistance and appearance of newer antibiotics like carbapenems and polymyxins in the market.

A study conducted by Purohit et al³⁸ showed that 23.0% ESBL producers were isolated from environmental sample which is similar to this study. In

contrast to the present study, Ibrahim et al³⁹ conducted a study in Bosnia and Herzegovina showed that 13.6% ESBL producers were isolated from environmental sample and George et al⁴⁰ in India showed that 10.5% ESBL producers were isolated from environmental sample both of which are lower than present study. Reason behind the difference might be since in both those studies, samples were collected from hospital environment and in this study environmental samples were collected only from burn unit. Burn units are overcrowded in our country, lot of infected patients stay in every ward. Burn wounds are usually extensive and difficult to take proper care, so cross contamination and spread of multidrug resistant organisms occurs in the ward environment. So multidrug resistant organisms are higher in burn wards than hospital environment.

Conclusion

In the present study, among the isolated gram-negative organisms, the highest proportion of organism was *Pseudomonas aeruginosa* from both burn wounds and environmental samples of burn unit of DMCH. Prevalence of drug resistance was high in all *Pseudomonas aeruginosa* isolated from clinical and environmental samples, and colistin was the most sensitive drug. Environment is a potential reservoir for bacterial infections in burn patients of DMCH. There is no significant difference in distribution, antibiotic resistance pattern and ESBL production between gram-negative organisms isolated from clinical and environmental samples of burn unit of Dhaka Medical College Hospital.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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Authors' contributions

Md. Faizur Rahman: Research concept, study design, protocol writing, responds to reviewer's comments, developing data collecting tools, data collection, data analysis & interpretation of results, writing manuscript, revise manuscript; Rubaiya Binte Kabir: Data analysis & interpretation of results, writing manuscript, revise manuscript; S. K Saiful Alam: Protocol writing, writing manuscript, revise manuscript. S.M. Shamsuzzaman: Research concept, study design, protocol writing, data analysis & interpretation of results, writing manuscript, revise manuscript. All authors revised the content and approved the

manuscript.

Data Availability

Data are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

Ethical approval for the study was obtained from the institutional Research Review Committee (Memo no. MEU-DMC/ECC/2016/230). As this was a prospective study the written informed consent was obtained from all study participants. All methods were performed in accordance with the relevant guidelines and regulations.

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ORCID

Md. Faizur Rahman: <https://orcid.org/0000-0002-0537-8091>
 Rubaiya Binte Kabir: <https://orcid.org/0000-0002-3643-9424>
 SK Saiful Alam: <https://orcid.org/0009-0006-3956-0066>
 SM Shamsuzzaman: <https://orcid.org/0000-0003-2886-8840>

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