Original Article

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Microbiology Section

Device Associated Hospital Acquired Infections in a Tertiary Care Hospital in Western Odisha

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ABSTRACT

Introduction: Hospital Acquired Infection (HAI) is defined as infection that is acquired after 48 hours of admission in hospital for a reason other than that infection and the infection was neither present nor incubating at the time of admission. Device Associated Hospital Acquired Infections (DAHAIs) mainly Central Line Associated Blood Stream Infection (CLABSI), Ventilator Associated Pneumonia (VAP) and Catheter Associated Urinary Tract Infection (CAUTI) pose significant threat to patients associated with prolonged hospital stays, greater healthcare costs and increased mortality. Surveillance of Device Associated Infections (DAI) can reduce the incidence of Nosocomial Infections (NI) by as much as 32% and lead to reduced healthcare costs.

Aim: To determine the microbiological profile of device associated HAI and to find the antimicrobial susceptibility pattern of the isolated organisms.

Materials and Methods: This was a hospital based cross-sectional study conducted in the Department of Microbiology, from November 2015 to October 2017. The study was targeted at three common DAHAIs: CAUTI, CLABSI and VAP. Patients admitted to clinical wards with 48 hours of indwelling devices like urinary catheter, central line and with endotracheal intubation developing signs and symptoms of DAI were included in the study. Specimen was collected with all aseptic precautions. Samples were processed by standard bacteriological methods. Isolates obtained were characterised by biochemical methods. Antibiotic susceptibility tests were done by Kirby Bauer disc-diffusion method. Total of 425 samples were included in the study of which 152 (35.76%) showed positive growth and in 273 (64.24%) samples culture was sterile. The samples were collected from Intensive Care Unit (ICU) and various wards. The results were expressed in terms of mean, percentage and rate.

Results: A CAUTI was the most common 53.28%, followed by VAP 37.51% and then CLABSI 9.21%. *Escherichia coli* was most commonly isolated organism 38 (23.45%) followed by *Staphylococcus aureus* 30 (18.51%). In CAUTI *Escherichia coli* (38.27%) was most commonly isolated and *Acinetobacter baumannii* (32.25%) was most commonly seen in VAP and in CLABSI *Candida* spp. (31.57%) was predominantly isolated.

Conclusion: This study gave an insight into the incidence and prevalence of DAHAIs and helps in instituting various interventional strategies to prevent these infections.

Keywords: Antimicrobial susceptibility, Surgical device, Ventilator associated pneumonia

INTRODUCTION

The HAI is defined as infection that is acquired after 48 hours of admission in hospital for a reason other than that infection and the infection was neither present nor incubating at the time of admission [1]. These infections are a significant cause of prolonged hospital stay and causes increased morbidity and mortality in hospitalised patients. The World Health Organisation (WHO) has estimated that at any given time, over 1.4 million people worldwide are suffering from an infection acquired in a healthcare setting [2]. Between 5-10% of patients admitted to acute care hospitals acquire an infection during hospitalisation. The urinary tract is the most commonly involved site of all HAIs (30-40%), surgical wound (15-20%) and lower respiratory tract infections (15-20%) next most frequent, followed by blood stream infection (5-15%) [3]. HAI are frequently encountered in ICUs because of the severity of underlying diseases, the frequency of invasive interventions and the injudicious use of wide spectrum antibiotics. It has been reported that ICU account for 25% of HAI, even though they occupy only approximately 10% of the bed capacity of the hospital [4].

The DAHAIs mainly CLABSI, VAP and CAUTI pose significant threats to patients associated with prolonged hospital stays, greater healthcare costs and increased mortality [5,6]. The frequency, epidemiology, microbiological spectrum, and antimicrobial resistance patterns of microorganisms that cause DAI vary among institutions and can change from year to year. In addition, Multidrug Resistant (MDR) pathogen infections are on the rise, which further complicates the management of these infections. Therefore, hospital specific and even unit specific antimicrobial resistance trends for DAI causing organisms should be determined to initiate early and effective empiric antimicrobial therapy [7].

The WHO distributes programmes such as guidelines on hand hygiene in healthcare to limit the rate of healthcare derived infections for both the patients and healthcare providers [8]. Surveillance of DAI can reduce the incidence of NI by as much as 32% and lead to reduced healthcare costs. The use of prevention protocols and hygiene education could significantly reduce the rate of HAI. The aim of this study was to find the prevalence of DAHAI in a tertiary care hospital of Western Odisha, India, also to determine the microbiological profile of device associated HAI and to find the antimicrobial susceptibility pattern of the isolated organisms.

MATERIALS AND METHODS

This was a hospital based cross-sectional study conducted in the Department of Microbiology from November 2015 to October 2017 after getting approval from Institutional Ethical Committee with No.2015/P-I-RP/140. The informed consent was taken prior collection of sample. The study was targeted at three common DAIs: CAUTI, CLABSI and VAP as defined by the CDC's National Nosocomial Infections Surveillance (NNIS) system criteria [Table/Fig-1] [9]. The patients who fulfilled all the criteria were diagnosed to be suffering from specific DAI.

Surveillance of DAHAI	Device criteria	Symptom criteria	Culture criteria
CAUTI	Urinary catheter in place for >2 days, if removed, symptoms must be on same day or next day after removal	Fever, suprapubic pain or tenderness, lower back pain or tenderness, urgency, frequency and dysuria	1or 2 organism ≥10^5 CFU/mL
VAP	Mechanical ventilation for >2 days, if removed, symptoms must be on same day or next day after removal	Clinical Pulmonary Infection Score (CPIS) >6, fever, Chest X ray, WBC count, New/persistent/progressive infiltrates	ETA >10^5 CFU/mL
CLASBI	Central line in place for >2 days, if removed DOE must be on same day or next day after removal	Fever, chill, hypotension	1. Positive blood culture from CVC and PVC yielding same organism with 10^3 CFU/mL 2. Quantitative blood culture no CFU from CVC was minimum 5 fold > than PVC 3. Distal 5 cm segment culture-colony count ratio > 4 to 10:1 between CVC and PVC 4. Differential time to positivity- 2 hrs

[Table/Fig-1]: Surveillance of Device Associated Hospital Acquired Infections (DAHAI) [9].
CAUTI: Catheter associated urinary tract infection; VAP: Ventilator associated pneumonia; CLASBI: Central line-associated blood stream infection; WBC: White blood cell; CFU:Colony forming unit; CVC: Central venous catheter; PVC: Peripheral venous catheter; DOE: Date of event; ETA: Endotracheal aspirate

Inclusion criteria: Patients admitted to clinical wards with 48 hours of indwelling devices like urinary catheter, central line and with endotracheal intubation developing signs and symptoms of DAI were included in this study.

Exclusion criteria: Patients admitted to hospital with device, implants which are difficult to access and patients with diagnosis of sepsis were excluded in this study.

For Catheter Associated Urinary Tract Infection (CAUTI)

Collection and transport- Urine specimen was collected with all aseptic precautions. The catheter tubing was clamped off above the port to allow collection of freshly voided urine. The wall of the tubing was cleaned with 70% ethanol and 5-10 mL of urine was aspirated via a sterile needle and syringe and transferred into a sterile container [10]. The urine sample was immediately sent to laboratory for processing.

Processing and identification- Urine was inoculated onto Cystine Lactose Electrolyte Deficient (CLED) agar by standard loop method for semiquantitative culture, plates were incubated aerobically at 37ºC for 24 hours. Bacterial colony count >10^5 CFU/mL as taken as significant and with not more than two organisms isolated was also considered significant [11].

For Ventilator Associated Pneumonia (VAP)

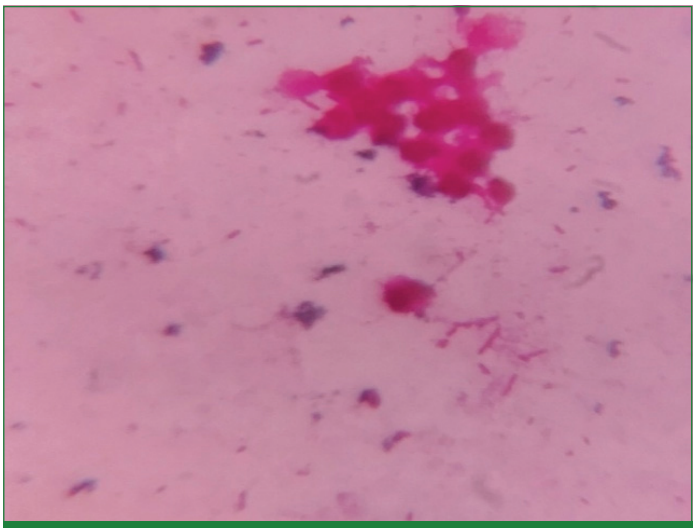
Collection and transport- Based on Clinical Pulmonary Infection Score (CPIS), endotracheal aspirates were obtained under strict aseptic precautions using a suction catheter with a mucus extractor. The samples were immediately transported to the laboratory for processing [3].

Processing and identification- Gram stain was done for the sample within first hour of collection [Table/Fig-2]. Sample was inoculated onto 5% sheep blood agar plate and CLED agar plate and incubated aerobically for 24 hour at 37°C. Growth of organism >10^5 CFU/mL was taken as significant, growth of any organism below the threshold was assumed due to contamination or colonisation [12].

For Central Line Associated Blood Stream Infection (CLABSI)

Collection and transport- Using all aseptic precautions, 5 mL of blood was drawn simultaneously from Central Venous Catheter (CVC) and Peripheral Venous Catheter (PVC) and collected in 50 mL of Brain Heart Infusion (BHI) broth. When catheter tip was collected, skin around The catheter site was disinfected and after removing distal 5 cm segment was cut-off with a sterile scissor and collected in sterile container. The samples were immediately transported to the laboratory [13].

Processing and identification- Blood collected in BHI bottle was incubated aerobically at 37°C and examined daily for turbidity, gas bubbles, appearance of small colonies in broth or on surface or along the wall of the of the bottle. Subculture was done on blood agar and CLED agar by removing few drops of well mixed inoculums and incubated at 37ºC [14]. Distal 5 cm segment of intravascular catheter was cultured by standard semiquantitative method by rolling 4-5 times across the surface of blood agar plate with the help of sterile forcep and incubated at 37ºC. After overnight incubation plates were examined for growth of similar organisms in both the cultures by colony morphology.



[Table/Fig-2]: Gram stain of endotracheal aspirate showing pus cells and gram negative bacilli in 100X magnification.

Antimicrobial susceptibility testing- Antimicrobial susceptibility test was performed for all the pure isolates by Kirby-Bauer disk diffusion method as per Clinical and Laboratory Standards Institute (CLSI) M00-S26 guidelines [15].

STATISTICAL ANALYSIS

Data were collected in Microsoft Excel sheet. The results were expressed in terms of mean, percentage and rate.

RESULTS

During the study period from November 2015 to October 2017, a total of 425 samples were included in the study of which 152 (35.76%) showed positive growth and cultures were sterile in 273 (64.24%) samples. The samples were collected from ICU and various wards [Table/Fig-3].

Eighty one urine samples from catheterised patients, 57 endotracheal aspirates from mechanically ventilated patients and 14 blood samples drawn simultaneously from central and PVC and CVC tip showed positive growth [Table/Fig-4].

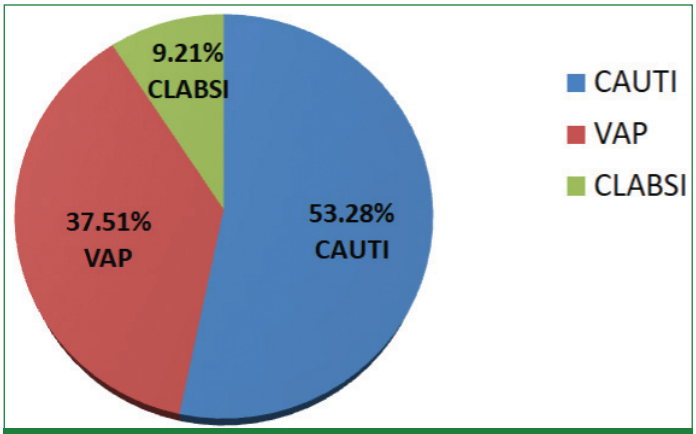
During this period 152 (35.7%) developed DAHAI with CAUTI being most common followed by VAP and then CLABSI [Table/Fig-5].

Wards	Total number	Positive growth
ICU	198	102 (51.5%)
Medicine	78	17 (21.8%)
Surgery	84	21 (25%)
Urology	25	5 (20%)
Nephrology	21	4 (19%)
Paediatric	11	2 (18.1%)
Oncology	4	1 (25%)
Orthopaedic	4	0
Total	425	152

[Table/Fig-3]: Distribution of samples from various wards (N=425).

S. No.	Specimen	Total number	Positive growth
1	Urine	174	81 (46.5%)
2	Endotracheal aspirate	153	57 (37.2%)
3	Blood, CVC Tip	98	14 (14.2%)
	Total	425	152

[Table/Fig-4]: Distribution of various samples (N=425).



[Table/Fig-5]: Distribution of Device Associated Hospital Acquired Infections (DAHAIs).

Most of the patients with DAHAIs belonged to age group between 46-60 years are 47/152 (31%) and 61-75 years are 41/152 (27%) [Table/Fig-6].

Age (in years)	Number	Male	Female	Positive growth
0-15	11	1	1	2 (1.3%)
16-30	95	14	11	25 (16.4%)
31-45	105	5	20	25 (16.4%)
46-60	89	15	32	47 (31%)
61-75	94	20	21	41 (27%)
>75	31	9	3	12 (7.9%)
Total	425	64	88	152 (100%)

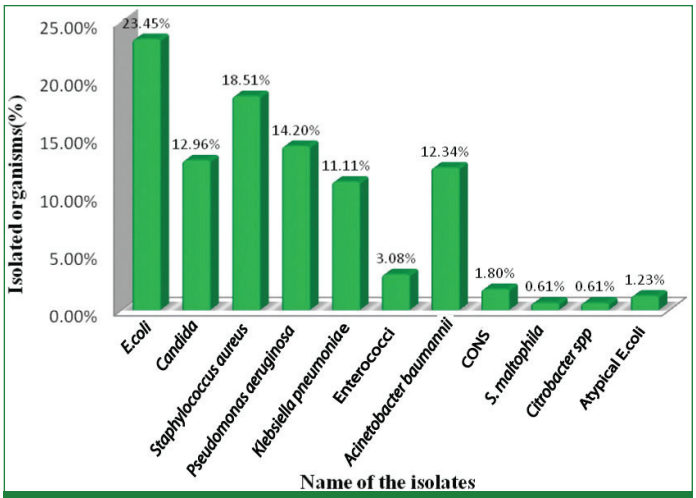
[Table/Fig-6]: Age and gender wise distribution of patients with Device Associated Hospital Acquired Infections (DAHAIs).

Out of 152 positive growth, 142 (93.4%) were of monomicrobial origin and polymicrobial growth were seen in 10 (6.6%) cases where two different types of organisms had grown [Table/Fig-7]. *Escherichia coli* was most commonly isolated 38/162 (23.45%) followed by *Staphylococcus aureus* 30/162 (18.51%) [Table/Fig-8].

In CAUTI *E. coli* (38.27%) was most commonly isolated followed by *Pseudomonas aeruginosa* (16.04%), *Acinetobacter baumannii* (32.25%) was most commonly grown in VAP and in CLABSI *Candida* spp. (31.57%) was predominantly isolated [Table/Fig-9]. In CAUTI, 59/81 (72.81%) were females and 22/81 (27.16%) were males. In VAP, 32/57(56.14%) were males and 25/57 (43.85%) were females and in CLABSI 10/14 (71.42%) were males and 4/14(28.57%) were females [Table/Fig-10].

Devise associated infections	Number of cases with monomicrobial growth	Number of cases with polymicrobial growth (2 different organisms)	Total number of specimen with growth	Total number of isolated organisms
CAUTI	81	-	81	81
VAP	52	5	57	62 (52+10)
CLABSI	9	5	14	19 (9+10)
Total	142	10	152	162

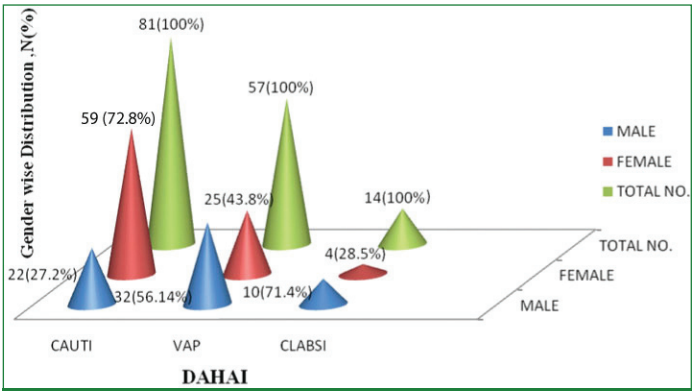
[Table/Fig-7]: Distribution of total number of DAHAIs (N=152) and total number of organisms (N=162) based on monomicrobial or polymicrobial origin.



[Table/Fig-8]: Distribution of isolated organisms.

Organism isolated	CAUTI (no. %)	VAP (no. %)	CLABSI (no. %)	Total (no. %)
Escherichia coli	31 (38.27)	5 (8.06)	2 (10.52)	38 (23.45)
Candida	9 (11.11)	6 (9.67)	6 (31.57)	21 (12.96)
Staphylococcus aureus	14 (17.2)	12 (19.35)	4 (21.05)	30 (18.51)
Pseudomonas aeruginosa	13 (16.04)	10 (16.12)	0	23 (14.2)
Klebsiella pneumoniae	10 (12.34)	7 (11.29)	1 (5.26)	18 (11.11)
Enterococci	2 (2.46)	1 (1.61)	2 (10.52)	5 (3.08)
Acinetobacter baumannii	0	20 (32.25)	0	20 (12.3)
CONS	0	0	3 (15.78)	3 (1.8)
Stenotrophomonas maltophila	0	0	1 (5.26)	1 (0.6)
Citrobacter spp.	0	1 (1.61)	0	1 (0.6)
Atypical *E. coli*	2 (2.46)	0	0	2 (1.23)
Total	81	62	19	162

[Table/Fig-9]: Distribution of organisms (N=162) isolated in CAUTI, VAP and CLABSI.



[Table/Fig-10]: Gender wise distribution of device associated hospital acquired infections (DAHAIs) (N=152).

The antimicrobial susceptibilty pattern of gram positive and gram negative organisms is presented in tabular form [Table/Fig-11]. The predominant isolate was *E. coli* which showed high level of resistance to cephalosporins, ceftazidime (84.2%), cefuroxime (78.9%) and aminoglycoside group of drugs, gentamicin (81.5%), amikacin (78.9%) but showed less resistance to carbapenems,

Antibiotics	*S.aureus* (n=30)	CONS (n=3)	Enterococci (n=5)	*E. coli* (n=38)	*Klebsiella* (n=18)	*Citrobacter* (n=1)	Atypical *E. coli* (n=2)	*Pseudomonas* (n=23)	*Acinetobacter baumannii* (n=20)	*S. malto-phila* (n=1)
Penicillin	28 (93.3)	2 (66.6)	4 (80)	-	-	-	-	-	-	-
Amoxiclav	-	-	1 (20)	-	-	-	-	-	-	-
Piperacillin-Tazobactam	-	-	-	32 (84.2)	14 (77.7)	0	0	9 (39.1)	6 (30)	0
Cefoxitin	7(23.3)	-	-	-	-	-	-	-	-	-
Cefuroxime	-	-	-	30 (78.9)	13 (72.2)	1 (100)	2 (100)	6 (26)	15 (75)	1 (100)
Ceftazidime	-	-	-	32 (84.2)	13 (72.2)	0	1 (50)	18 (78.2)	15 (75)	1 (100)
Ceftrixone	14 (46.7)	2 (66.6)	2 (40)	28 (73.6)	9 (50)	1 (100)	2 (100)	12 (52.1)	16 (80)	1 (100)
Gentamicin	16 (53.3)	0	1 (20)	31 (81.5)	12 (66.6)	0	1 (50)	19 (82.6)	15 (75)	1 (100)
Amikacin	15 (30)	0	1 (20)	30 (78.9)	9 (50)	0	0	11 (47.8)	16 (80)	0
Ciprofloxacin	6 (20)	1 (33.3)	1 (20)	25 (65.7)	14 (77.7)	1 (100)	0	19 (82.6)	20 (100)	1 (100)
Clindamycin	0	0	2 (40)	-	-	-	-	-	-	-
Chloramphenicol	25 (83.3)	2 (33.3)	1 (20)	-	-	-	-	-	-	-
Erythromycin	26 (86.6)	3 (66.6)	1 (20)	-	-	-	-	-	-	-
Linezolid	0	0	0	-	-	-	-	-	-	-
Vancomycin	0	0	0	-	-	-	-	-	-	-
Imipenem	-	-	-	4 (10.5)	3 (16.6)	0	0	4 (17.3)	3 (15)	0
Meropenem	-	-	-	1 (5.5)	2 (11.1)	0	0	3 (13)	3 (15)	0
Polymyxin B	-	-	-	2 (11.1)	1 (5.5)	0	0	3 (13)	2 (10)	0
Colistin	-	-	-	1 (5.5)	2 (11.1)	0	0	2 (8.6)	1 (5)	0

[Table/Fig-11]: Resistance pattern of the bacterial isolates, n (%).

imipenem (10.5%), meropenem (5.5%). All the isolates were mostly sensitive to polymyxin B and colitsin. Of non fermenters, the predominant isolate was *Pseudomonas aeruginaosa* which showed high level resistance to ceftazidime (78.2%), gentamicin (82.6%), ciprofloxacin (82.6%) but showed less resistance to polymyxin B (13%) and colistin (8.6%). All gram positive isolates were sensitive to vancomycin and linezolid.

In this study 30 *Staphylococcus aureus* were isolated among them, 7/30 (23.3%) were found to be Methicilin Resistant *Staphylococcus aureus* (MRSA).

DAI rate was expressed as the number of DAI per 1000 device days. The overall DAI rate combined for different wards and ICUs was found to be 6.86 DAI per 1000 device days [Table/Fig-12].

DAI	Device days	Positive growth (No.)	Distribution of DAI (%)	DAI rate (Per 1000 device days)
CAUTI	8208	81	53.2	9.8
VAP	5880	57	37.5	9.6
CLABSI	8064	14	9.3	1.73
Total	22,152	152	100	6.86

[Table/Fig-12]: Distribution of DAHAI rate per 1000 device days.

DISCUSSION

Healthcare associated infections, particularly those acquired following insertion of devices, are serious cause of concern for hospitals. Regular surveillance of DAI in any healthcare setting is therefore highly informative not only to clinicians but also to administration in deciding strategies for the prevention and control of such infections [16]. During the study period, a total of 152 DAI were observed, CAUTI represented 53.28%, VAP 37.51% and CLABSI 9.21%. The overall HAI rate associated with indwelling devices in the present study was found to be 35.7% or 6.8 per 1000 device days which was in accordance with a study done in 2004 in New Delhi by Habibi S et al., and in study done by Shalini S et al., the overall rate of NI was 27.4% and the rates of the urinary, respiratory and the intravascular catheter related infections were 55.52%, 35.78% and 11.52%, respectively [17,18].

In order to determine the rate of CA-UTI, 174 cases of urinary catheterisation from various wards and ICUs were studied. An 81 patients were confirmed for having CA-UTI. The overall rate of CA-UTI was 53.8% or 9.8 per 1000 device days; which was consistent with the findings of study conducted by Guanche-Garcell H et al., Candevir A et al., [19,20] and the rate of CA-UTI in various studies have ranged from 4.4-56.5% or 1.7 to 30 infections per 1000 device days [18-20]. In CAUTI *E. coli* (38.27%) was most commonly isolated which was not significantly associated with study done by Guanche-Garcell H et al., where they found 64% of *E. coli* [19].

Total of 153 patients were suspected for having VAP, 57 patients were confirmed microbiologically ensuing an infection rate of 37.5% or 9.6 per 1000 device days; which was in accordance with study done by Mathai AS et al., and remarkably high when compared to study conducted by Singh S et al., [21,22]. Rates of VAP have ranged from 10.5-34.8% in different studies. Longer duration on device increases the risk of DAI as was also seen in the present study. *Acinetobacter baumannii* (32.25%) was predominantly isolated from VAP. Study conducted by Aravind M and Navaneeth BV showed an infection rate of 9.3% or 1.73 per 1000 device days [3]. This was not associated with studies conducted by Datta P et al., and Parameswaran R et al., [23,24]. In CLABSI *Candida* spp. (31.57%) and *Staphylococcus aureus* (21.05%) were most frequent isolates which was in accordance with study done by Parameswaran R et al., [Table/Fig-13] [24].

	CAUTI	VAP	CLABSI
Similar studies	Guanche-Garcell H et al., [19] *E. coli* (64%)	Aravind M and Navaneeth BV [3] *Acinetobacter baumannii* (44.3%)	Parameswaran R et al., and Inan D et al., [24,25]
Current study	*E. coli* (38.27%)	*Acinetobacter baumannii* (32.25%)	*Candida* spp. (31.57%)

[Table/Fig-13]: Comparison of Prevalence of organisms with other studies [3,19,24,25].

The organisms commonly found in HAI are nosocomial pathogens prevalent in the hospital environment. The organisms isolated in the present study were *E. coli*., *Acinetobacter baumannii*, *Candida* spp., *Pseudomonas aeruginosa*, *K. pneumoniae*, CONS, *Staphylococcus aureus* and Enterococci; similar to findings in different studies [3,18,21-25].

Total 23.3% of *S. aureus* isolates were MRSA. *E. coli*, *Klebsiella* spp., *Acinetobacter baumannii* and *Pseudomonas aeruginosa* had maximum sensitivity to carbapenem group of drugs (imipenem, merpenem) which was in accordance with study done by Shalini S et al., Parameswaran R et al., and Inan D et al., [18,24,25]. Very

high resistance was observed to cephalosporin (cefuroxime and ceftazidime) group of drugs, Frequently isolated organisms like *Pseudomonas aeruginosa*, *Acinetobacter* spp. etc, even showed high resistance to beta lactam and beta lacatamase inhibitor combination (piperacillin-tazobactam) and fortunately all strains of *S. aureus* (100%) were sensitive to vancomycin and linezolid, which was significantly associated with study conducted by Datta P et al., [23]. An 84% of *Staphylococcus aureus* infections were caused by methicillin-resistant strains in study done by Rosenthal VD et al., and in Mehta A et al., study, 87.5% of all *Staphylococcus aureus* were caused by meticillin-resistant strains which completely deferred from present study as only 23.3% of MRSA was obtained [26,27].

Antibiotic sensitivity pattern of non fermenting gram negative organisms (*Pseudomonas aeruginosa*) suggested that most strains were resistant to the commonly used beta lactam antibiotics but they were highly sensitive to antibiotics like polymyxin B, colistin, imipenem which is in accordance with study done by Mohanty D et al., [12].

The present study on the microbiological profiles of the HAI showed that the rate is high, even though it was within the reported range. This study gives an insight into the incidence and prevalence of device associated HAI and helps in instituting various interventional strategies to prevent these infections.

Limitation(s)

The study would have been more useful if antifungal susceptibility could have been tested. Mortality data could not be collected.

CONCLUSION(S)

Healthcare acquired infections have been associated with substantial morbidity, mortality, prolonged length of hospital stay and increased healthcare costs. The risk of the development of NI was directly related to the duration of hospital stay and duration of device use. The prolonged use of indwelling devices needs careful prophylactic standards of monitoring. The empirical and indiscriminate use of antibiotics should be avoided to curtail the emergence and spread of drug resistance among nosocomial pathogens. Guidelines should be proposed by the institute on prevention and control of DAHAI, if followed strictly it will decrease the rate of these infections and financial burden of the patients.

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