Original Article

Retrospective Analysis of Hospital Acquired Infection and Antibiotic Resistance in Coronary Care Unit (CCU), Adult, and Pediatric Cardiology Wards

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ABSTRACT

Background: Antibiotics resistance is an paramount threat affecting the whole world but nowhere situation is as gloomy as in India. No study till date regarding epidemiology of hospital acquired infections in coronary care units(CCU) and cardiology wards from India. From Indian perspective it is the first observational study to analyse microbiological profile and antibiotic resistance in CCU.The purpose of this observational study is to explore the epidemiology and importance of infections in CCU patients.

Methodology: After ethics committee approval, the records of all patients who were admitted in coronary care units, adult and pediatric cardiology wards surgery between January 2020 and December 2021 were reviewed retrospectively. The type of organism,source of infection ,age wise distribution and seasonal variability among patients who developed hospital acquired infection (HAI) were determined.

Results: 271 patients developed microbiologically documented HAI during from January 2020 to December 2021. Maximum number of organisms(78/271 28.78%) are isolated from urinary samples ,followed by blood stream(60/271 22.14%) and Endotracheal tube (54/271 19.92%). Acinetobacter baumanii (53/271, 19.5%) being the most common isolate among all the samples taken .Acinetobacter was the most frequent pathogens isolated in patients with LRTI and blood stream infection while E.coli was from urinary tract infection . In the adult population, infection with E. coli(24.6%) is the most common followed by Klebsiella pneumoniae (12.8%) and Acinetobacter baumanii (10.1%). In the pediatric population Acinetobacter baumanii (38.6%%) is the most common followed by Klebsiella pneumoniae (20.5%) and Methicillin Resistant Staphylococcus aureus, MRSA (6.8%).Commonly used antibiotics eg ciprofloxacin,ceftazidime and amikacin were found to be resistant against the top three isolates.

Conclusion: Urinary tract was the most common site of infection and Gram-negative bacilli, the most common pathogens in adult as well as pediatric population. Antibiotic resistance was maximum with commonly isolated microorganisms.

Keywords: Antibiotic resistance, cardiology, hospital acquired infection

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INTRODUCTION

Use of antibiotics was started in the 1940s. Since then, it has saved millions of lives. However, these can cause side effects and lead to the development of antibiotic

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resistance. Antibiotics resistance is an paramount threat affecting the whole world but nowhere situation is as gloomy as in India. In November 2019, the Centers for Disease Control and Prevention (CDC) released an Antibiotic resistance report which showed reductions in the incidence of infections caused by carbapenem-resistant Acinetobacter species, multidrug-resistant *Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococcus, and drug-resistant candida species. It also revealed an increasing incidence of extended-spectrum beta-lactamase producing Enterobacterales and drug-resistant *Neisseria gonorrhoeae* infections and multidrug-resistant *Candida auris*. It is found that nearly twice as many Americans died from antibiotic-resistant infections in 2013 as was previously estimated (44,000, rather than 23,000).[1,2] Infectious disease mortality rate in India is approximately 400 per 1 lakh population,[3,4] roughly twice as compared to in U.S.[5] In the last decade, antibiotic consumption has increased by 35 percent from 2000 to 2010, with a frequent use of last resort antibiotics carbepenems (45%) and polymyxins (13%).[6] Due to weak regulations and reluctance for use of antibiotic stewardship, antibiotic abuse is unrestrained in India, which had led to the high resistance rates, and no study till date regarding epidemiology of hospital acquired infections (HAI) in Cardiology Intensive Care Units (CICU) or Coronary Care Units (CCU) from India. From an Indian perspective, it is the first observational study to analyze microbiological profile and antibiotic resistance in CCU. The purpose of this observational study is to explore the epidemiology and importance of infections in CCU patients.

METHODOLOGY

After Ethics committee approval (IEC-18/03.02.2023), all patients admitted in cardiology including intensive care unit, adult, and pediatric wards between Jan 2020 and Dec 2021 were included in this retrospective observational study. Data were retrospectively collected. The incidence and distribution of hospital acquired infection (HAI), the microorganisms, and their antibiotic resistance were determined. The Centers for Disease Control and Prevention criteria were used for defining HAIs. CDC defines HAI as an adverse reaction to infectious agent or toxin without evidence of infection or incubating infection at the time of admission. Infectious agents can be endogenous body sites such as skin, nose, mouth, gastrointestinal (GI) tract, or vagina or exogenous such as patient care personnel, visitors, patient care equipment, and medical devices. Simple presence of microorganism (colonization) or inflammation as a response to injury or chemical agents is not considered as HAI.[7] Major types of HAIs classified in accordance with CDC guidelines which are commonly encountered in cardiac wards and CCUs are listed in Table 1.[8]

RESULT

In total, 2478 samples were obtained during this period**.** Out of total samples, 271 (1.11%) patients developed microbiologically documented HAI. Maximum number

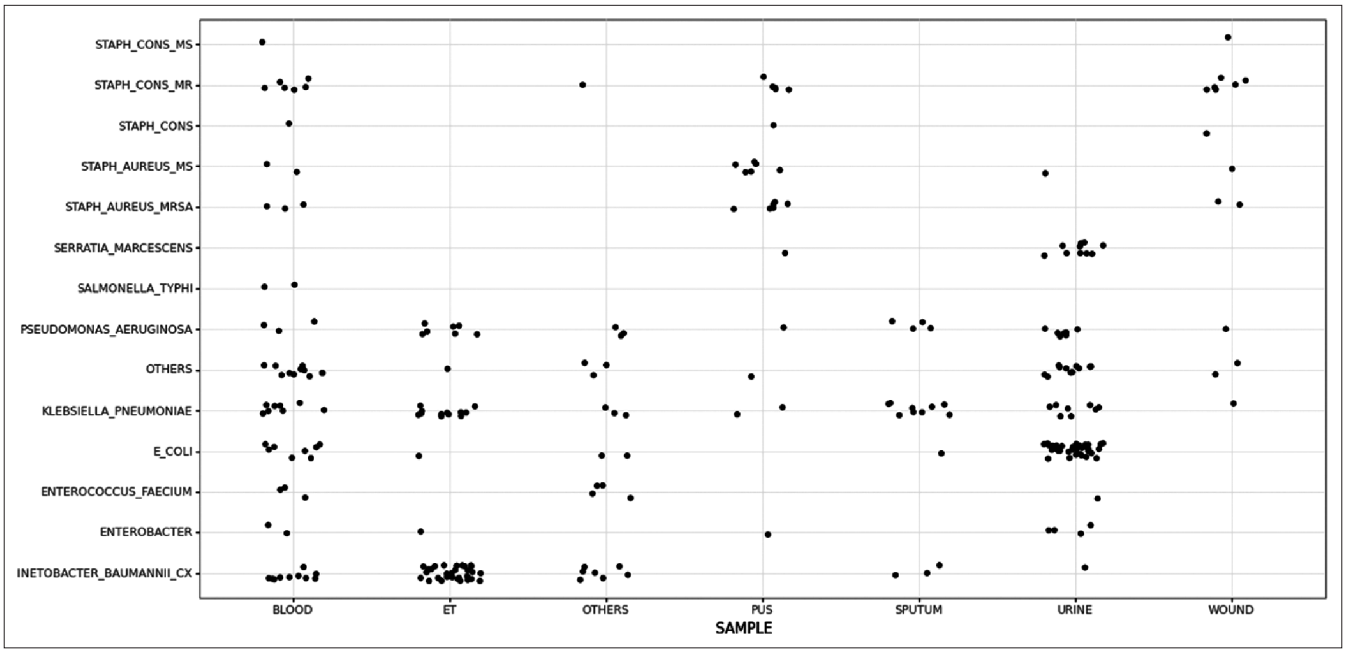

Figure 1: Source of sample versus organism isolated. ET: Endotracheal tube

of organisms (78/271 28.78%) were isolated from urinary samples, followed by blood stream (60/271 22.14%) and endotracheal tube (54/271 19.92%) [Figure 1]. The gram-negative organisms dominated the spectrum of the isolated organisms from total 271 samples taken from patients admitted in the cardiology department with *Acinetobacter baumannii* (53/271, 19.5%) being the most common isolate among all the samples taken. It was most frequently isolated from endotracheal tube samples (32/54, 59.25%), followed by *Klebsiella pneumoniae* (12/54, 22.22%) and *Pseudomonas aeruginosa* (7/54, 12.96%). Again in the blood stream isolates, *Acinetobacter baumannii* (10/60, 16.67%) dominated the spectrum followed equally by *Escherichia coli* (8/60, 13.33%) and *Klebsiella pneumoniae* (8/60) and then the Methicillin-resistant CONS (6/60, 10%) and Methicillin-resistant *Staphylococcus aureus* (3/60, 5%). Among the urinary isolates, *Escherichia coli* (35/78,44.87%) was most commonly isolated. Of notable importance is the isolation of opportunistic pathogen *Serratia marcescens* (10/78, 12.8%) in urinary samples. The age-wise stratification of the organisms isolated was also performed [Figures 2 and 3]. It was found that most of the pediatric population had

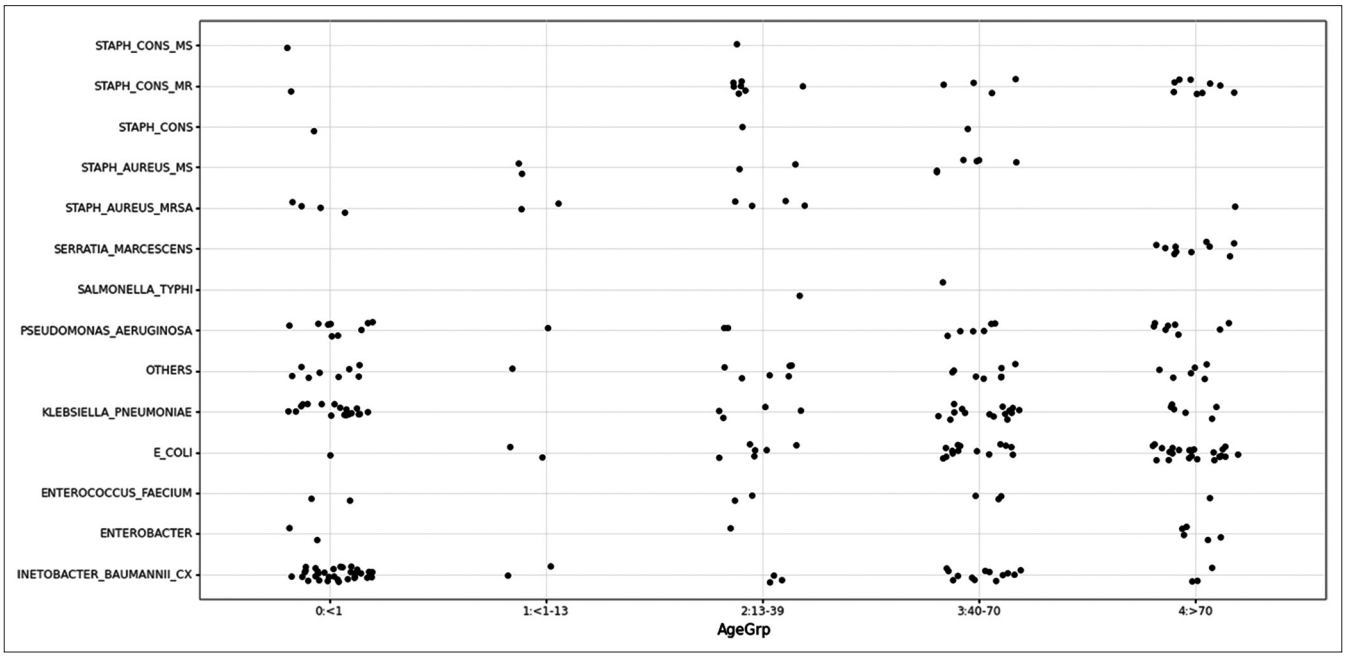

Figure 2: Distribution of organism according to age groups

Table 1: Major types of HAI in accordance with CDC guidelines

Types	Acronym	Subtypes	Acronym
Urinary tract infection	UTI	Symptomatic urinary tract infection Asymptomatic bacteriuria	SUTI
		Other infections of the urinary tract	ASB
			OUTI
Surgical site infection	SSI	Superficial incisional primary SSI	SIP
		Superficial incisional secondary SSI	SIS
		Deep incisional primary SSI	DIP
		Deep incisional secondary SSI	DIS
Bloodstream infection	BSI	Laboratory-confirmed bloodstream infection Clinical sepsis	LCBI
			CSEP
Pneumonia	PNEU	Clinically defined pneumonia	PNU1
		Pneumonia with specific laboratory findings	PNU2
		Pneumonia in immunocompromised patient	PNU3
Cardiovascular system infection	CVS	Arterial or venous infection	VASC
		Endocarditis	ENDO
		Myocarditis or pericarditis	CARD
		Mediastinitis	MED
Gastrointestinal system infection	GI	Gastroenteritis Gastrointestinal (GI) tract	GE
NEC Necrotizing enterocolitis		Hepatitis Intraabdominal, not specified elsewhere	GIT
			HEP
			IAB
Lower respiratory tract infection, other than pneumonia	LRI	Bronchitis, tracheobronchitis, tracheitis, without evidence of pneumonia	BRON
		Other infections of the lower respiratory tract	LUNG

Acinetobacter baumannii infection (38.6%) which is also one of the most common isolate in HAIs. The other most common organisms isolated in the pediatric population are *Klebsiella pneumoniae* (20.5%) and Methicillin-resistant *Staphylococcus aureus*, *MRSA* (6.8%). In the adult population, infection with *E. coli* (24.6%) was the most common followed by *Klebsiella pneumoniae* (12.8%) and *Acinetobacter baumannii* (10.1%). *Methicillin-resistant Coagulase negative Staphylococcus (MR-CONS)* (11.2%) and *Serratia marcescens* (5.6%) are mainly seen in the adult population. There is no significant correlation among the age group and the organisms isolated in the present study. Infection

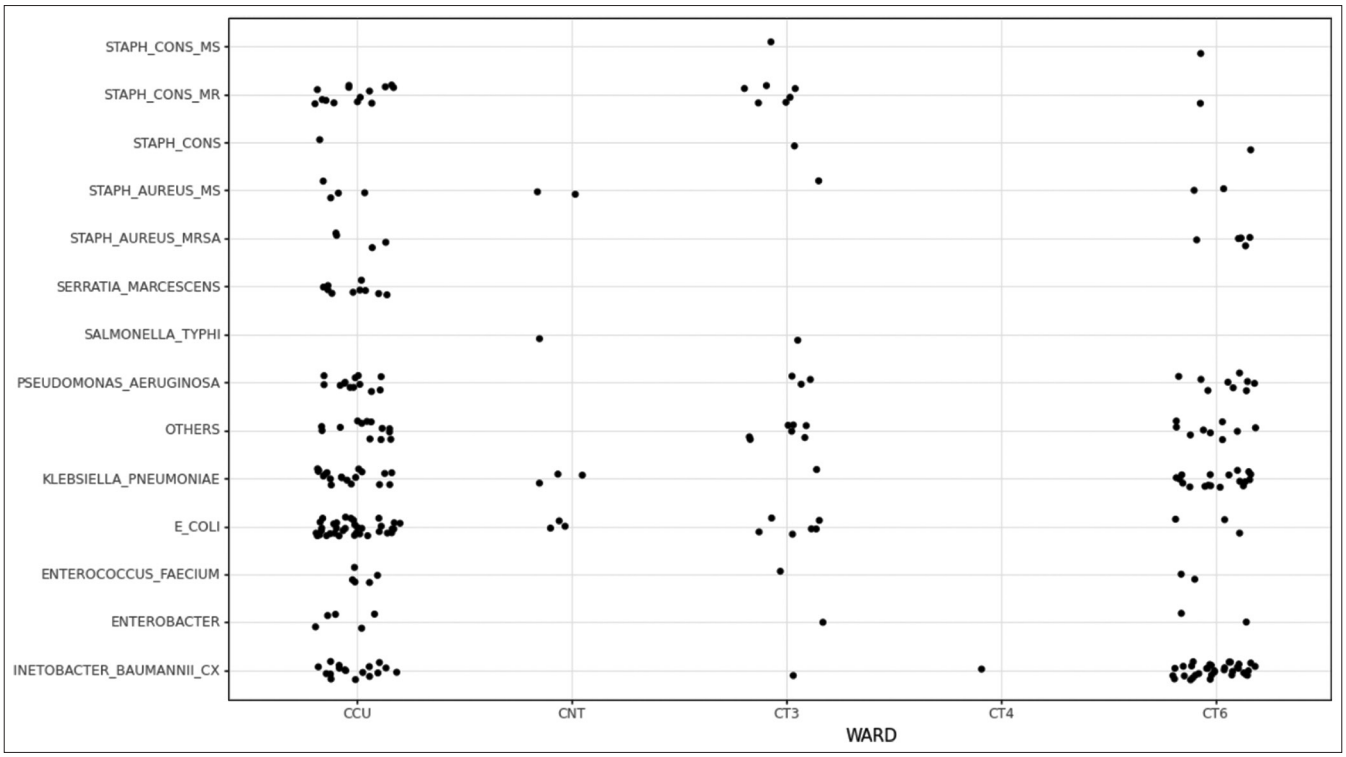

Figure 3: Distribution of organism according to adult and pediatric cardiology ward and coronary care unit, CCU: Coronary care unit, CT3, CT4, CNT: Adult cardiology ward, CT6: Pediatric cardiology ward

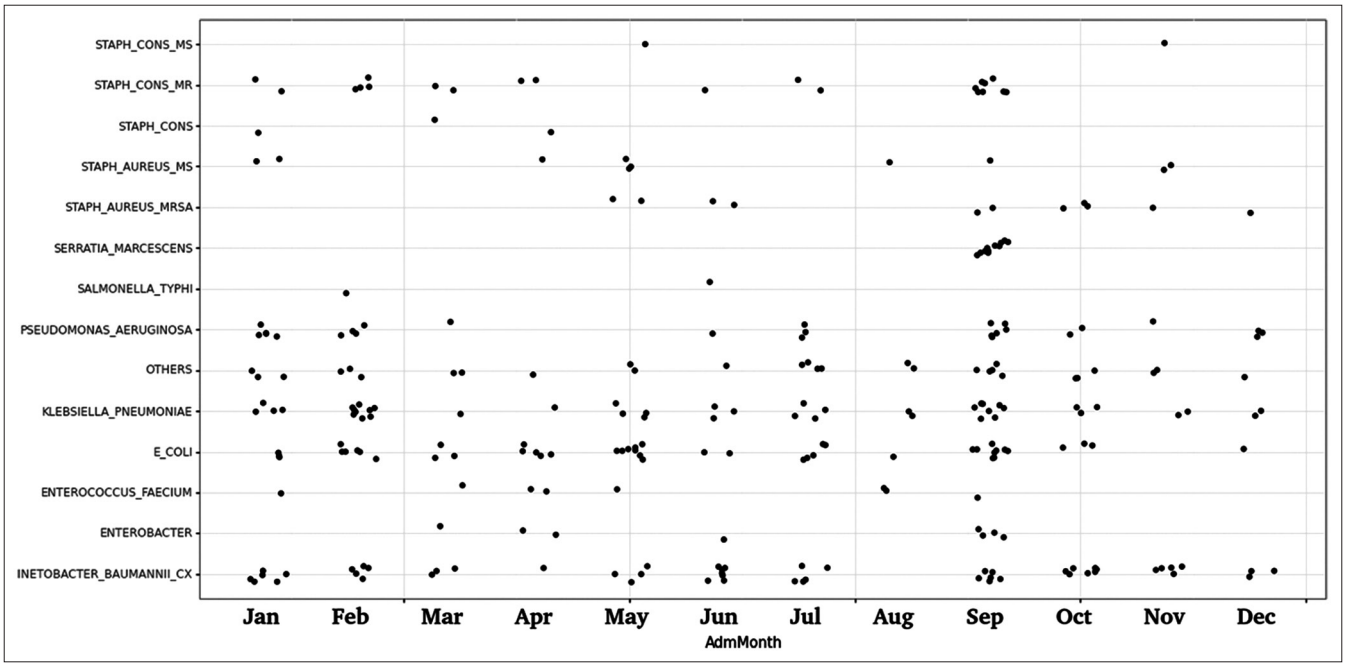

Figure 4: Distribution of organism according to months

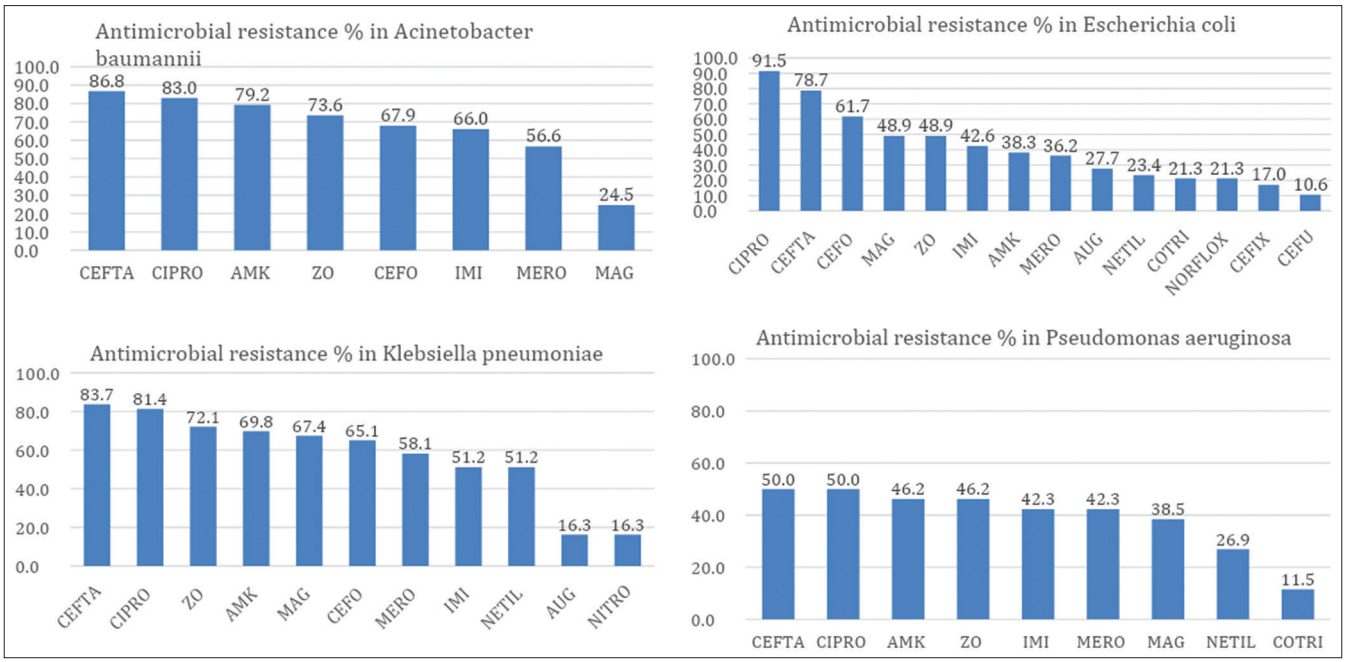

Figure 5: Antibiotic resistance pattern - Top 4 organisms. Note: >10% resistance included in the graph, CEFTA: Ceftazidime; CIPRO: Ciprofloxacin; AMK: Amikacin; ZO: Ofloxacin; CEFO: Cefoperazone; IMI: Imipenem; MERO: Meropenem; MAG: Sulbactam and Cefoperazone; AUG: Amoxicillin and Clavulanic acid; NETIL: Netilimicin; NITRO: Nitrofurantoin; COTRI: Cotrimoxazole; NORFLOX: Norfloxacin; CEFIX: Cefixime; CEFU: Cefuroxime

control measures need to be adhered to and intensified to prevent infections. The maximum number of isolates seen in the month of September may be due to conducive environment at the end of summer season and onset of winter season [Figure 4]. Antimicrobial resistance pattern of commonly isolated microorganism is summarized in Figure 5. Antimicrobial resistance in *Acinetobacter baumannii* was 86.8% (ceftazidime), 83.0% (ciprofloxacin), and 79.2% (amikacin), respectively. Antimicrobial resistance in *Escherichia coli* was 91.5% (ciprofloxacin), 78.7% (ceftazidime), and 61.7% (cefoperazone), respectively.

DISCUSSION

Acinatobacter baumannii is frequent among most commonly isolated organism in patients with ICU-acquired pneumonia.[9] It has been observed in a study from pediatric ICU setting also.[10] We have found that *Acinatobacter baumannii* is the most commonly isolated organism in ET and blood samples. In a study from Greek intensive care units (ICU),[11] a similar spectrum of organisms were isolated from blood stream infections. Gram-negative organisms are most commonly isolated in urinary samples with *E. coli*, being the most common as was seen in the study from Catherine Zatorski *et al*.[12] We found *Acinatobacter baumannii* as the most common organism in pediatric patients. It is also the most frequent organism in pediatric ICU settings, as has been mentioned by Logan LK *et al*.[13] in their study between 1999 and 2012 in the United States regarding the increase in Cephalosporin-resistant *A. baumannii* isolates in children. Apart from this, the other common organism was klebsiella pneumoniae and MRSA which corroborated with other studies from South Africa[14] as well as Malaysia,[15] citing the importance of measures to be taken to prevent colonization of these organisms in the hospital setting. A ten-year systematic review on the burden and epidemiology of *E. coli* bacteremia confirms the substantial burden of *E. coli* bacteremia in older adults.[16] A study from Latin America also highlighted the importance of increasing resistance in community-acquired urinary tract infection due to *E. coli* and *Serratia marcescens*.[17] A case–control study was performed to identify the risk factors for *S. marcescens* acquisition in urine in an extended outbreak of *Serratia marcescens* bacteriuria that lasted for years in a neurosurgical intensive care unit (NSICU) in Korea.[18] It was found that patients of *S. marcescens* isolation had either central venous catheterization or urine sampling frequently and were on third-generation cephalosporins. In a study, gram-negative organisms were seen during summer and gram-positive cocci during winter, showing host susceptibility to organisms in different seasons due to physiologic changes in the host.[19] Table 2 enlisted several published observational data regarding the prevalence of various micro-organisms across the globe.[20-31]

Table 2: List of observational data regarding the prevalence of various micro-organisms and antimicrobial resistance across the globe

Name of Study	Year	No.	Micro organisms	AMR in antibiotics
Tran *et al*.[20]	2017	220	*Acinetobacter* (*n*=75) *Klebsiella* (*n*=39), *Pseudomonas aeruginosa* (*n*=29)	Ceftriaxone (88%), Ceftazidime (80%), Ciprofloxacin (77%), Cefepime (75%), Levofloxacin (72%).
Bissenova *et al*.[21]	2017 2012-2016	4228	*Klebsiella pneumoniae* 8.9%, *Pseudomonas aeruginosa* 7.5%, *Staphylococcus aureus* 6.9%, Coagulase-Negative *Staphylococci* 5.3%, and *Candida* spp. 3.4%	NA
Ghanshani *et al*.[22]	2015	623	*Staphylococcus aureus* *Escherichia coli* 18.3% *Klebsiella* 19.7% *Pseudomonas* spp 14%	NA
Ramanath *et al*.[23]	2017-18	167	*E. coli* 27.5% *Klebsiella species* 16%, *E. coli* with ESBL producer 8%.	Amoxiclav 44.3% Ampicillin 43.1%, Cefotaxime 37.7%, Ceftazidime 31.1%, Ciprofloxacin 31.1%, Amikacin 28.7%, Ofloxacin 25.7%, Levofloxacin 22.8%, Ceftriaxone 22.9%, Cefepime 21.6%.
Pawar, *et al*.[24]	2005-2006 Cardiac Surgical ICU	3161	*Pseudomonas aeruginosa* 37.8% *Klebsiella species* 24.2% *E. coli* 22.0% *Enterobacter species* 6.1%	NA
Sheth *et al*.[25]	2010-2011 critical care unit and intensive cardiac care units	1007	*Klebsiella pneumoniae* 28.6% *Pseudomonas aeruginosa* 16.3%	NA
Singh *et al*.[26]	2015	1944	*Escherichia* coli 5.5% *Klebsiella* 23.7% *Pseudomonas* spp 38%	NA
Ravalet al.[27]	2012	554	*Escherichia coli* 19.6% *Klebsiella* 20% *Pseudomonas* spp 27%	NA
Patwardhan *et al*.[28]	2008	272	*Escherichia* coli 27% *Klebsiella* 19% *Pseudomonas* spp 13.2%	NA
Dasgupta *et al*.[29]	2015	40	*Escherichia coli* 17.5% *Klebsiella* 12.5% *Pseudomonas* spp 32.5%	NA
Wattal *et al*.[30]	January 2008 to December 2011	22,491	coagulase nega-tive *staphylococcus* (CoNS) (20.3%) *Candida spp*.(17.5%). Gram negative *bacilli* (GNB), Gram positive *cocci* (GPC), and fungi were isolated in 49%, 33%, and 18% cases, respectively. Among GNB, *Klebsiella* spp. was the commonest	NA
Sahu *et al*.[31]	January 2013 to December 2014	6864	*Acinetobacter* (32%) and *Klebsiella* (19%). *Pseudomonas* 13%	NA

AMR: Antimicrobial resistance

Although CCU patients are usually admitted directly without recent surgery, infections, or antibiotic therapy, there are some differences between CCU and other critical care area in terms of distribution of nosocomial infection sites, pathogens, and device associated infection rates. There have been few studies in United States about nosocomial infections in CCU. The mean overall patient infection rate was between 2 and 5 infections per 100 patients. CCU usually have low HAI compared to other ICUs mainly because of the lower use of invasive devices such as central lines, ventilators, or urinary catheters. This also supports the causative role of these devices in HAIs. Urinary tract infection, pneumonia, and primary bloodstream infection represent almost 75% of all infections. *Staphylococcus aureus* (21%) was the most common species from pneumonia and *Escherichia coli* (27%) from urine. Only 10% of reported urine isolates were *Candida albicans*. *Staphylococcus aureus* (24%) was the more common bloodstream isolate than enterococci (10%). One study from our institute has reported that incidence of nosocomial infection is 4.6% in cardiac surgery ICU. Lower respiratory tract (LRT) was the most common site for HAI and Acinetobacter was the most commonly detected organism with high resistance.[31]

Strict infection control measures are usually not being followed in CCUs compared to cardiac surgery

ICUs. This study included combined data of ward, CCU, and showed 1.11% incidence rates of hospital acquired infection rates among these patients. We suggest that close monitoring for the presence of preventable HAI should be performed. Implementation of preventive strategies like meticulous hand hygiene, minimizing the duration of invasive cardiac support devices, best practices to decrease LRT infection, or VAP (ventilator associated pneumonia) are use of non-invasive positive pressure ventilation in selected patients, daily interruption of sedation and assess the readiness for extubation on daily basis, position of head >30 degree, and ET tube with subglottic suction and early mobilization. For prevention of blood stream infection, use of central venous catheters should be restricted in patients with established indications only and removed as soon as possible once not indicated. Use of aseptic technique, avoid using femoral vein site for CVC placement, ultrasound guidance, and use of minimal luminal diameter CVCs are advocated. For the prevention of UTI, urinary catheterization should be performed by a trained person, in patients with established indications and removal as early as possible. Use of condom catheterization in males without urinary retention, preconnected catheters with tubing system, portable bladder scanners, and cleaning of urethral meatus with antiseptic solution should be strictly implemented.[8]

CONCLUSION

Urinary tract was the most common site of infection and gram-negative bacilli, the most common pathogens in adult as well as pediatric patients with cardiac diseases. Antibiotic resistance was maximum with commonly isolated microorganisms. There is no significant correlation among the age groups and the organisms isolated in the present study. Infection control measures need to be adhered to and intensified to prevent infections.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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