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Surveillance and Risk factors analysis of Catheter Associated Urinary Tract Infections (CAUTI) in the patients admitted to the Critical care units of a tertiary care center, Piparia, Vadodara, Gujarat.

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ABSTRACT

Background: Catheter associated Urinary Tract Infections (CAUTI) is considered as global health concern, leading to the significant morbidity and mortality in the ICU patients.

Aim of study: To conduct the surveillance and risk factor analysis of CAUTI patients.

Methods: The Prospective cross-sectional study was conducted on 85 patients with indwelling urinary catheter admitted in the ICUs of a tertiary care centre, Gujarat. Further identification of the uropathogens and its Antibiotic susceptibility tests were reported by Vitek -2 Automated systems. Various Risk factors related to both the health care workers and patients were analysed statistically.

Results: The CAUTI incidence rate were 12.01/1000 urinary catheter days. Hand Hygiene (*P*= 0.02, OR-2.245), Periurethral cleaning (P=< 0.0001, OR-3.675), Use of sterile gloves (P=< 0.0001, OR- 2.057), Maintaining Closed drainage system (*P* = 0.04, OR- 2.057) were significantly associated with the reduction in the rates of CAUTI. Age-group > 50 years (*P*= 0.04, OR- 1.650) and length of hospital stay > 7 days (*P*= 0.006, OR- 3.245) significantly upsurges the risk of CAUTI. The most common uropathogens were *Escherichia coli* (46%) and *Klebsiella pneumoniae* (19%). Majority of them were Multidrug resistant (MDR).

Conclusions: Incidence of CAUTI is higher in the ICU patients, so unvarying surveillance of CAUTI, Stringent infection control practices and antimicrobial stewardship program (ASMP) is the pressing priority.

Keywords: Catheter-associated urinary tract infection (CAUTI), Intensive Care Unit (ICU), Infection control, Multi drug resistance (MDR), Risk factors, Uropathogens.

INTRODUCTION

Healthcare Associated infections (HAIs) are the major cause of morbidity and mortality worldwide [1]. Major HAIs include Catheter-associated Urinary Tract Infections (CAUTI),

Ventilator Associated Pneumonia (VAP) and Central Line Associated Blood Stream Infections (CLABSI) [1,2]. According to the CDC, NHSN (National Health Safety Network) guidelines, CAUTI is defined as a urinary tract infection where an indwelling urinary catheter was in place for more than 2 consecutive days in an inpatient location on the date of event, with the day of device placement is day 1 AND an indwelling urinary catheter was in place on the date of event or the day before [3]. Around the world, CAUTI is regarded as the most prevalent HAI, accounting for up to 40% of HAIs, where an indwelling urinary catheter is accountable for about 70-80% of UTIs in healthcare settings [3]. The intensive care units (ICUs) use devices on average 45-79% more frequently than in hospital wards 17-23%, that is why the infections are of major public health concern as they lead to longer hospital stays, higher healthcare costs, with surge in morbidity and mortality [4].The most predictable cause of CAUTI includes both catheterisation and the duration of catheterisation, other risk may comprise, improper catheter installation, inadequate aseptic technique, poor hand hygiene, inadequate asepsis of the urethral orifice opening, colonisation of drainage bag, underlying illness, and older age [5]. CAUTI can lead to several complications such as Prostatitis, epididymitis, cystitis, pyelonephritis, osteomyelitis, meningitis, and septicaemia in patients. Microorganisms can enter to the urinary tract through either intraluminal spread (an open drainage bag or a hole in the closed drainage system) or extraluminal spread (Patients' endogenous flora or HCWs Hands) [6]. In ICUs in low- and middle-income countries the incidence of CAUTI per 1000 catheter days is 5.5 to 8.8[7]. Pooled Indian CAUTI data is 1.60 which is significantly better than the benchmark figure of CDC-NHSN at 2.09 and INICC at 6.5 [8]. Surveillance of CAUTI is imperative to monitor trends for detection of outbreaks and the assessment of efficacy of CAUTI prevention programs. The study was envisioned to perform the surveillance of CAUTI and determine its incidence in ICUs, identify various modifiable risk factors, and to detect the resistance pattern of the uropathogens.

MATERIALS AND METHODS

- **Study Design & setting:** The Prospective Cross-sectional study was conducted at the Microbiology laboratory of a Tertiary care hospital, Piparia, Waghodia, Vadodara, Gujarat.
- **Ethical considerations:** Approval was taken from Sumandeep Vidyapeeth Institutional Ethical Committee (SVIEC) prior to the initiation of work. (Dated-12/10/2021, Approval no.- SVIEC/ON/Medi/BNPG20/D21160). A written informed consent was obtained from each patient enrolled in the study.
- **Study Period:** The study was conducted for a period of 1 year from September 2021-August 2022.
- **Sample size**: 85 Catheterized Urine samples
  Using the below formula, we got the sample size of 83

$$\text{Sample size} = \left[\frac{Z^2 \times P\,(1-P)}{d^2} \right]$$

  - Z=1.96
  - P=expected proportion in population based on previous studies- 0.5%
  - d= absolute error of precision-5%
- **Inclusion criteria:**
  a. All the symptomatic patients having an indwelling urinary catheter that was in place for >2 consecutive days in an inpatient location on the date of event or removed the day before the date of event (According to the CDC NHSN guidelines) [3]
  b. Those admitted in the critical care units.
  c. Those giving the consent.

- **Exclusion criteria:**
  a. Catheterized patients with age < 2 years of age.
  b. Patients showing signs and symptoms of UTI within 2 calendar days of catheterization
  c. Patients with condom catheters, suprapubic catheters, and percutaneous nephrostomy tubes.

Methodology: Data was collected regarding the demographic details, date of admission, date of catheterization, duration of catheterization, indication for catheterization, co-morbidities, antibiotic therapy etc. via a validated questionnaire. Patients were monitored from the time of inclusion in the study to the date of removal of catheter and followed up till 1 day after removal of catheter to look for signs and symptoms suggestive of urinary tract infection. Data regarding the Infection control practices followed by the health-care workers were also noted in a checklist made for CAUTI.

a. Sample collection: Urine samples were collected in a wide mouth, screw-capped, leakproof, sterile container after the disinfection of catheter sample collection port with 70% isopropyl alcohol (IPA), from the catheter tube after clamping distally.

b. Culture was done by using a calibrated loop that is 0.001-mL- on Sterile Hi- Chrom agar, MacConkey agar plates and Cysteine Lactose Electrolyte deficient (CLED) media (Media procured from Hi media labs, Mumbai) by streaking method as well as a semi-quantitative method. The colonies were further identified with antimicrobial susceptibility testing by using Vitek-2 compact system (Bio Mérieux). Antibiotic sensitivity testing was performed using the minimum inhibitory concentration (MIC) method as per the latest CLSI guideline (M100) [9] .

c. According to the CDC NHSN guidelines [3] Surveillance Criteria for CAUTI (Symptomatic Urinary Tract infections (SUTI 1a) Criteria, CDC NHSN, Table 1) was only if they accomplish all the 3 NHSN surveillance diagnostic criteria:

- Catheter in place for > 2 calendar days
- Presence of at least one symptom such as fever > 38 °C, suprapubic tenderness, or costovertebral angle pain.
- Growth of a significant number ($\geq 10^5$ CFU/mL) of Uro pathogens

***Those cultures with Mixed flora (>2 species of microorganisms), Growth of Candida species or yeast not otherwise specified, Mold and dimorphic fungi were not considered as pathogen reporting CAUTI** [3].

RESULTS

The study was conducted for the period of 1 year from September 2021 to August 2022. A total of 85 catheterised patients admitted to the Critical care units (MICU and PICU), fulfilling the inclusion criteria, with varied symptoms and comorbidities were enrolled in the study. Out of 85, 43(51%) were males and 42 (49%) were females with varied age-group ranging from 10-80 years. 65% patients were from the Rural community and rest 35% were from the urban community. Acute kidney disease, Chronic kidney disease, Acute cerebrovascular accident (hemiparesis), altered sensorium, and Urosepsis accounted for most of the ICU admission diagnosis. Some or other patient had either Diabetes (n=12,14%) or Hypertension (n=11, 13%) or both together (n=7, 8%). Majority of the patients (n=74, 87%) were admitted in the Medical ICU and rest patients (n=11, 13%) in Paediatric ICU. Looking to the duration of catheterisation in hospital, we found that out of 85 patients, 61 (72%) patients had catheter for >7 days length of hospital stays, 16 patients (19%) had for 4 to 7 days and 8 patients (9 %) had catheter for < 4 days.

Out of 85 catheterised patients, 37(44%) developed CAUTI (Fulfilling SUTI 1a criteria) [3]. Total catheter days calculated were 3079 catheter days, which resulted in the overall

CAUTI incidence rates of 12.01/1000 urinary catheter days using the formula (CDC NHSN)

CAUTI incidence rate = $\frac{\text{Number of CAUTI cases}}{\text{Total No. of Urinary catheter -days}} \times 1000$

= 37x1000/3079 catheter days

=**12.01/1000 urinary catheter days**

In the present study, the most common etiology found associated with CAUTI was *Escherichia coli* (n=17, 20%), followed by *Klebsiella pneumoniae* (n=7, 8%), *Pseudomonas aeruginosa* (n=4, 5%), *Candida albicans* (n=4, 5%), *Enterobacter cloacae* (n=2, 2%), and *Proteus mirabilis, Providencia rettgeri* and *Acinetobacter baumannii* (n=1, 1%) each. **(Chart 1)**

In Table 1 We have analysed several modifiable risk factors related to the practices done by the health care workers, affecting CAUTI rates and amongst that, Performing Hand Hygiene before and after the insertion (P= 0.02, OR-2.245), Periurethral cleaning (P=< 0.0001, OR-3.675), Use of sterile gloves (P=< 0.0001, OR- 2.057), Maintaining Closed drainage system (P = 0.04, OR- 2.057), Following Standard precautions all the time (P= 0.0006, OR- 2.160), were significantly associated with the reduction in the rates of CAUTI. Use of single packet jelly (*P* = 0.13) or empirical antibiotics (*P*= 0.23) did not have significant impact in reducing the CAUTI rates.

Table 2 depicts the analysis of various risk factors of CAUTI associated with patients. Out of 37 CAUTI cases, age group > 50 years (*P*= 0.04, OR- 1.650), Rural community (86% cases, *P*=0.003, OR-3.490) and length of hospital stay > 7 days (90 % cases of CAUTI, *P*= 0.006, OR- 3.245) and stay in Medical ICU (*P* = 0.08, OR- 5.351) significantly upsurges the risk of development of CAUTI. While Gender (Male- 51% vs Female- 49%, *P*= 0.92, OR- 0.969) did not display any implication in development of CAUTI.

Chart 2 exhibited that Majority of *Escherichia coli* and *Klebsiella pneumoniae* strains were Multi drug resistant (MDR). *Escherichia coli* showed 100% resistance to Ceftriaxone, 94% resistance to Amoxycillin, Nalidixic acid and Ticarcillin, 88% resistance to norfloxacin, ceftazidime and Piperacillin/ Tazobactum. ***Klebsiella pneumoniae*** strains showed absolute resistance towards Amoxycillin, Piperacillin/ Tazobactam, Ceftriaxone, Imipenem, Nitrofurantoin, Gentamycin Norfloxacin, Cotrimoxazole. 88% resistance towards ceftazidime, Cefoperazone sulbactam, Amikacin and Nalidixic acid. 71% towards Cefepime and Ciprofloxacin.

Enterobacter cloaca showed 100% resistance towards Cefepime, Nitrofurantoin, and Fosfomycin, while 50% resistance was seen towards Amoxycillin Piperacillin/ Tazobactam, Ceftazidime, Ceftriaxone Cefoperazone sulbactam, Imipenem, Amikacin, Ciprofloxacin, Gentamycin, Norfloxacin and Nalidixic acid. ***Proteus mirabilis*** and ***Providentia rettgeri*** strains exhibited 100% resistant to all the antibiotics. ***Pseudomonas aeruginosa*** showed 100% resistance towards Tigecycline, 75% resistance towards Piperacillin/Tazobactam, Ceftazidime, Imipenem, Meropenem, Ciprofloxacin, Levofloxacin and Co-trimoxazole. Most sensitive antibiotic was Minocycline (75%), followed by 50% sensitivity towards Cefoperazone sulbactam, Cefepime, amikacin and Gentamycin. ***Acinetobacter baumannii*****:** 100% resistance towards Ticarcillin, Imipenem, Gentamycin, Levofloxacin, Ciprofloxacin, while 100% strains were sensitive towards Tigecycline, Co-trimoxazole, Ceftazidime, Cefepime, Cefoperazone sulbactam and Piperacillin tazobactam

DISCUSSION

Over 50 lakhs patients in the ICUs undergo catheter insertion, which increases their risk of development of CAUTI and its complications. All over the world, Urinary Catheter is considered as the sole primary risk factor for the development of UTI. As multiple factors like aseptic technique during the insertion, hand hygiene, catheter care, and duration of catheterization can affect the incidence of CAUTI, a holistic approach becomes mandatory to reduce the incidence of CAUTI. [10] As the proportion of patients with catheterization in ICUs will always be higher than in the wards, the present study was carried out at a rural based tertiary care hospital for prospective surveillance of CAUTIs over a period of one year.

Overall magnitude of CAUTI in present study was 44% (37/85), accords well with the study done by Anggi A *et al*., [11] in 2019 (44.4%), and higher than the other similar studies done by Shiva verma *et al.,* [12] in 2017 (15.95%) and Smriti Parihar et al [13] in 2023 (14.67%).

CAUTI incidence rates were calculated as 12.01 per 1000 urinary catheter days in 85 catheterized patients with 3079 catheter days. The rates were quite in accordance with the study done by Shabina Habibi [14] *et al.,* in AIIMS New Delhi (11.3%), while the rates were lower than the findings of the International Nosocomial Infection Control Consortium (INICC) [15] in Mongolia (15.7%) which was a multicentric study, and study done by Binita Kashyap [16] (17.38%) and Shrestha et al [17] (30.21%). The total infection rates for CAUTI, in the ICUs of the seven hospitals that make up the International Infection Control Consortium (INICC) in seven Indian cities were **1.41 per 1,000 catheter days** [18]. In the south-eastern part of Asia, Europe, and the South and North Americas, the occurrence of catheter-acquired urinary tract contamination per 1,000 catheter days was 15.71, 8.99, and 5.70, respectively with a mean level of 8.50 [18]. Although the CAUTI rates in the present study does not accord the Pooled data from India, but also reveals a lot of disparity from place to place, which undoubtedly indicates that strict adherence practices of catheter care bundle, implementation of infection control practices and proper hand hygiene compliances should be amended in all the hospitals to diminish the burden of CAUTI.

The study could not confirm any Gender predisposition for the development of CAUTI, as in Males the rates were 51% and in females the rates were 49%. Both have almost equal potential to get the infection. The study revealed evidence challenging the notion that women were more susceptible to disease because they had shorter urethra.

The most common Aetiology was *Escherichia coli* (45%), followed by *Klebsiella pneumoniae* (19%), *Pseudomonas aeruginosa* (11%), which is in accordance to the other studies [12] It is reported that 40-72% of CAUTI in general worldwide is due to *E. coli* [19].

Uropathogenic *E. coli* plays an important role as it possesses Type I pili capable of binding to the urinary epithelium and preventing their elimination by urine flow [20, 21]. Capsule and Lipopolysaccharide helps to evade the host immune system. Similarly, *Klebsiella pneumoniae* is accused of being the second-most causative agent for CAUTI, approximating 8–16% [21]. It also expresses type 1 pili to adhere to the catheter, resulting in the initialization of biofilm formation and bladder colonization [22]. 4 cases (11%) of CAUTIs cases were due to the pathogenic yeast, *candida albicans* which is very much in sync with the results of study of Shiva et al. [12] in 2017.

Present study emphasizes on the role of various modifiable Risk factors like the techniques for urinary catheter insertion like Performing Hand Hygiene before and after the insertion (OR-2.245), Periurethral cleaning (OR-3.675), Use of sterile gloves (OR- 2.057), along with Urinary catheter maintenance like Maintaining Closed drainage system (OR- 2.057), were significantly associated with the reduction in the rates of CAUTI. The study accentuates that not doing Hand hygiene before the insertion of catheter increases the risk of CAUTI twice, similarly not doing

periurethral cleaning increases the risk 3.5 times. Length of the hospital stay > 7 days is also directly proportional to the risk of CAUTI and increases the risk thrice. More the stay, more will be the catheter days, which further is the most important risk for Bacteriuria. It is been highlighted by many authors that duration of catheterisation increases the risk by 3-7% daily. [22] Numerous studies reported that the longer the catheter remains indwelling inside the urethra, the higher the rate of bacteria colonizing the urinary bag and ascending in the drainage tubing towards the bladder, resulting in CAUTI [22]. Comorbidities like diabetes mellitus is major factor to cause Catheter associated urinary tract infection. DM can cause incomplete bladder emptying and cause microorganism colonization. In our study 48 % of cases showed comorbidities and Diabetes mellitus found in the largest no. of cases i.e., 14% of cases and DM with hypertension showed by 8% of cases, which is comparable to the many studies [11, 22].

Antimicrobial susceptibility pattern of the isolates obtained in this study showed that most of the Gram-negative bacilli were multidrug-resistant (MDR). all the isolates showed great variations in their susceptibility patterns. *Escherichia coli* showed 100% resistance towards 3rd generation Cephalosporins and Nalidixic acid followed by Ticarcillin, Amoxycillin and Piperacillin tazobactam. Similarly, ***Klebsiella pneumoniae*** strains showed absolute resistance towards Amoxycillin, Piperacillin/ Tazobactam, 3rd generation Cephalosporins, Carbapenems, Aminoglycosides, Nitrofurantoin, Fluroquinolones, Cotrimoxazole. 88% resistance towards Cefoperazone sulbactam, **Enterobacter cloaca** showed 100% resistance towards 4th generation Cephalosporins Nitrofurantoin, and Fosfomycin. ***Proteus mirabilis*** and ***Providentia rettgeri*** strains exhibited 100% resistant to all the antibiotics. ***Pseudomonas aeruginosa*** showed 100% resistance towards Tigecycline, 75% resistance towards Piperacillin/Tazobactam,3rd generation cephalosporins and carbapenems, fluoroquinolones and Co-trimoxazole. Resistance patterns are very much in agreement with other studies. [23, 24] The high resistance rate observed in our study might be attributed to the study's design, which focused on ICU patients. With varied co morbidities. Hence, antibiotic stewardship program plays an important role in hospitalized patients with UTI as it is very frequently encountered by treating physicians.

CONCLUSION: CAUTI rates have upsurged in the ICU patients, Unvarying Surveillance of CAUTI in ICUs with Stringent infection control measures is the need of an hour. Rates can also be curbed down by understanding the roles of various modifiable risk factor especially the catheter bundle care. Organisms causing CAUTI were usually MDR, which points towards the Establishment and implementation of an effective antimicrobial stewardship program (ASMP), which will optimise the irrational and indiscriminate use of antimicrobials, preventing the emergence of drug resistant strains in the environment.

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AUTHORS'CONTRIBUTION

Himani Pandya- conceptualized and designed the study. Tabish Ansari executed the study. Himani Pandya and Tabish Ansari wrote the manuscript. Sucheta Lakhani guided and revised the manuscript. All authors read and approved the final manuscript for publication.

ETHICS STATEMENT: This study was approved by the ethics committee of Sumandeep Vidyapeeth Dated-12/10/2021, Approval no.- SVIEC/ON/Medi/BNPG20/D21160.

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Tables and Chart

Chart 1: Uropathogens isolated from CAUTI patients

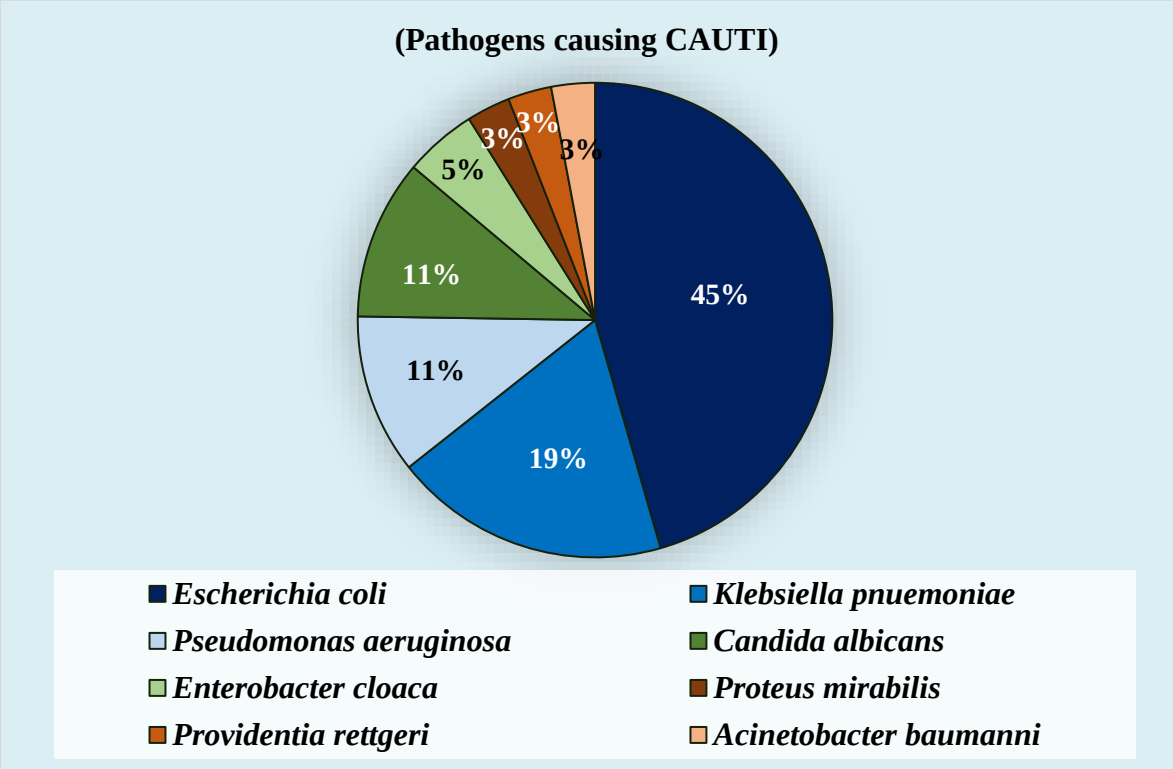

Table 1: Analysis of various risk factors (Related to the health care worker) associated with both CAUTI and NON CAUTI patients.

Characteristics		**Total (n=85)**	**CAUTI (n=37)**	**No signs of CAUTI (n=48)**	**Chi square**	***P* Value**	**Odd ratio**
Techniques for urinary catheter insertion							
Hand hygiene before and after insertion	**Yes**	77(90.5%)	30(39%)	47(61%)	5.1118	0.02	2.2458
	No	08(9.5%)	07(87.5%)	01(12.5%)			
Properly trained person	**Yes**	79(93%)	32(40.5%)	47(59.5%)	4.1609	0.0015	2.0573
	No	06(7 %)	5(83.3%)	1(16.7%)			
Using sterile gloves and standard precautions	**Yes**	66(77.6%)	20(30.3%)	46(69.7%)	21.012	<0.0001	2.0573
	No	19(22.4%)	17(89.5%)	2(10.5%)			
Periurethral cleaning	**Yes**	49(57.6)	10(20.5%)	39(79.5%)	25.161	<0.0001	3.6750
	No	36(42.4%)	27(75%)	9(25%)			
Single-use packet of lubricant jelly	**Yes**	61(71.8%)	23(37.7%)	38(62.3%)	2.2015	0.13	0.547
	No	24(28.2%)	14(58.3%)	10(41.7%)			
Factors associated with Urinary catheter maintenance							
Maintain closed drainage system	**Yes**	79(93%)	32(40.5%)	47(59.5%)	4.1609	0.04	2.0573
	No	06(7%)	5(83.3%)	1(16.7%)			
Maintain unobstructed urine flow	**Yes**	77(90.6%)	33(42.9%)	44(57.1%)	0.1504	0.68	1.166
	No	8(9.4%)	4(50%)	4(50%)			
Use of systemic antibiotics	**Yes**	6(7%)	4(66.7%)	2(33.3%)	1.4059	0.23	0.6266
	No	79(93%)	33(41.8%)	46(58.2%)			

*P value<0.05 is considered significant

Table 2: Analysis of various risk factors (Host factors) associated with both CAUTI and NON CAUTI patients.

Variables	Total n=85	CAUTI n=37	Chi-square	*p* value	Odd ratio
Gender	**Male** n=43 (51%)	19 (44%)	0.0091	0.92	0.9699
	Female n=42 (49%)	18 (43%)			
Age - Group	**< 50 years of age** n=45(53%)	15 (33%)	4.0442	0.049	1.650
	>50 years of age n=40(47%)	22 (55%)			
Socio-economic status (SES)	**Urban** n = 30 (35%)	5 (17%)	13.610	0.003	3.4909
	Rural n = 55 (65%)	32 (58 %)			
Admission in Intensive Care Unit (ICU)	**Medical ICU** 74 (87%)	36 (49 %)	6.0963	0.08	5.3514
	Pediatric ICU 11 (12%)	01 (9 %)			
Length of hospital stay	**<4 days** 8 (9 %)	2 (25%)	10.1564	0.006	3.2459
	4 to 7 days 16 (19 %)	2 (12.5%)			
	> 7 days 61 (72 %)	33 (54 %)			

*P value<0.05 is considered significant

Chart 2: Resistance pattern of *Escherichia coli* and *Klebsiella pneumonia*