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Original Article

Catheter-associated Urinary Tract Infections in a trauma care facility in India: trend over ten years

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Abstract

Introduction: Catheter-associated urinary tract infections (CAUTIs) are one of the most common device-associated infections acquired in a hospital. Trauma patients are highly susceptible to CAUTI, as catheterization is a lifesaving measure often required for their management. This study focuses on the profile of CAUTI, the organism profile with antibiotic susceptibility patterns, and the clinical outcomes in the ICUs of a trauma care center.

Methodology: A retrospective analysis of prospective surveillance data of patients in ICUs was done over a period of ten years (2010-2019) in a level 1 trauma center. A modified NHSN definition of CAUTI was used. Microbiological processing and antibiotic susceptibility profile was done based on standard guidelines. Clinical outcomes were considered for analysis.

Results: A total of 10,732 patients were included in the study, accounting for 98,131 patient days and 78,126 urinary catheter days (UCD). Among 546 patients, 577 episodes of CAUTI were recorded, giving a CAUTI rate of 7.4/1,000 catheter days. The average length of stay (LOS) of patients was 19.9 days. There was a significant relationship between UCD and the development of CAUTI. Orthopedic and spinal injuries (91%) accounted for the maximum device utilization ratio, followed by polytrauma (90%), miscellaneous injuries (88%), and head injuries (69%). CAUTI episodes were the highest in head injury patients. Gram-negative organisms (53.4%) dominated the pathogen profile. The crude mortality was 25.1%.

Conclusions: Surveillance of CAUTI with analysis of the organisms and the antibiotic susceptibility trend will help improve infection prevention practices and antibiotic stewardship programs in local hospital settings.

Key words: CAUTI; trauma; infection; ICU.

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Introduction

Healthcare-associated infections (HAIs) are preventable patient care-related complications. Most HAIs develop due to indwelling devices like catheters, central lines, or ventilators [1]. HAIs have been found to increase morbidity, mortality, and cost of treatment. Therefore, appropriate infection control and preventive measures should be undertaken based on the localized surveillance of HAIs.

Catheter-associated urinary tract infections (CAUTIs) are one of the most common device-associated HAIs. It accounts for one-third of HAIs that hospitals report in acute care settings, comprising 40% of the 2 million HAIs reported each year [2-4]. The risk of urinary tract infections (UTIs) is high, with almost 75% of patients admitted to hospitals undergoing urinary catheterization during their stay. In the intensive care unit (ICU) setting, 95% of UTI cases may be catheter-associated [5]. Surveillance of these cases is vital for establishing the trends of CAUTI, evaluating the organisms responsible, and their antibiotic susceptibility profile. Antimicrobial resistance is a major, unavoidable concern in healthcare. With the documentation of more multi-drug resistant organisms, especially in ICU settings, understanding their susceptibility trends is paramount.

Generally, 5-10% of patient admissions are complicated by an HAI. However, patients at a trauma care facility acquire HAIs exclusively due to their antecedent injury-related management [6]. Hospital-acquired-UTI (HA-UTI) in trauma patients develops mainly due to catheterization. The nature of their trauma requires prolonged use of catheters because of their impaired mobility and multiple surgical procedures. In such cases, the acquisition of an infection, especially by a multi-drug-resistant pathogen, affects the overall management and recovery.

Various researchers have studied the morbidity and mortality associated with CAUTI, but there is limited literature on CAUTI in trauma care facilities, especially in India. This study focuses on the profile of CAUTI in different types of trauma cases over ten years, the organism profile with antibiotic susceptibility patterns, and the eventual clinical outcomes with respect to their injuries.

Methodology

Study design

Retrospective analysis of prospective surveillance data from June 2010 to June 2019.

Ethical Consideration

The study was conducted after clearance from the Institute Ethics Committee. Informed consent was taken for all surgical procedures. However, informed consent was waived because of the retrospective nature of the study.

Study setting

The study was conducted at a level 1 trauma center in India, where the patients are referred from all over India. The center is part of a tertiary care hospital with approximately 2,500 beds and is a teaching institute. Of the total beds at the trauma facility, 32 are exclusively in the ICUs and 30 in the high-dependency units (HDUs). Ten nurses are designated hospital infection control nurses (HICNs), and a data entry operator assists their work.

Definitions

Targeted surveillance of HA-UTI was done based on modified Centres for Disease Control (CDC) National Healthcare Safety Network (NHSN) definitions [7]. CAUTI was defined as a patient with an indwelling catheter for over two calendar days who developed: a.) One or more of the following symptoms – fever > 38 °C, frequency, dysuria, urgency, suprapubic tenderness, and b.) Urine culture, positive with ≥ 10^5 colony-forming units/mL with not more than two organisms.

We have included *Candida* spp. in our analysis to understand its role, if any, in causing infections when patients are symptomatic.

Surveillance

Surveillance was started when the length of stay (LOS) at the hospital exceeded two calendar days. The HICNs visit every patient in the ICUs and HDUs and record complete details for the diagnosis of HA-UTI as per the UTI definition. The surveillance data is then entered into an indigenous HAI software. All the demographic, clinical, radiological, and laboratory findings are extracted from the hospital information system. The microbiology reports are extracted and entered into the software from the laboratory information system (LIS). All updates are incorporated in real-time. Vital parameters and clinical findings are recorded on a proforma for each patient in the ICU. This proforma includes the usage of catheters and the exact dates of their insertion/change/removal. After the records were brought to the laboratory, data was entered into a specifically designed software named ASHAIN (automated surveillance of hospital-acquired infections). The patients admitted to other units were followed up for two calendar days to detect any infection acquired in surveillance units (ICUs/HDUs).

Microbiology processing

All the samples were sent by the clinicians for diagnosis of infections based on their clinical suspicion. Standard methods were used for the microbiological processing of specimens [8]. The microbial identification was done using the Vitek-2 compact (Biomerieux, France) or, the Maldi-Tof system (Biomerieux, France). The antimicrobial susceptibility testing was done by the Vitek-2 compact susceptibility system (Biomerieux, France). Disc diffusion testing was done using the Kirby Bauer method for cases where the CLSI guidelines did not recommend Vitek 2. The broth microdilution method was used for the susceptibility test of bacteria against Colistin. The HAI-associated pathogens that met the CDC criteria were included in the database. The calculation of HA-UTI was done as per the definitions above. The antimicrobial susceptibility pattern was noted for these pathogens over the years, and their susceptibility was analyzed for the duration of the study.

Outcome analysis

The outcome was assessed based on the clinical data of the CAUTI cases. The outcomes evaluated were death, transfer from the ICU, discharge from the hospital, and leave against medical advice (LAMA). The length of stay was defined from admission to death or discharge.

Statistics

Comprehensive descriptive statistical measures were used. Two proportion tests were calculated.

Results

A total of 13,350 patients [11,132 (83.4%) males and 2,218 (16.6%) females] were admitted to these ICUs, accounting for a total of 102,677 ICU days. The pooled unadjusted average LOS in the ICU of all patients was 7.7 days (range 0-117) days. The average age of the patients was 33.1 years, with a range from 8 days to 99 years. The diverse traumatology for which they were admitted included head injury [7,023 (52.6%)], spine and orthopedic injuries [2,580 (19.3%)], polytrauma including abdominal and chest injuries [3,194 (23.9%)], and miscellaneous injuries comprising of vascular, degloving and gunshot injuries [553 (4.2%)].

The total number of patients who stayed in ICU for more than 2 days was 10,732. These comprised 1,771 (16.5%) females and 8,961 (83.5%) males. The average age of these patients was 33.4 years, ranging from 8 days to 98 years, and the median ICU stay was seven days, ranging from 3 days to 117 days. The total ICU days of these patients was 98,131 days.

During the study, 78,126 UCDs were recorded (range 3-117 days, median of five days). CAUTI episodes of 577 were noted, giving a CAUTI rate of 7.4/1,000 UCD. These 577 episodes occurred in 546 patients. The trauma for which they were admitted included head injury; 201 (36.8%), polytrauma inclusive of abdominal and chest injuries; 164 (30.1%), orthopedic and spine injuries; 154 (28.2%), and miscellaneous injuries; 27 (4.9%). The average length of ICU stay in the patients with CAUTI was 19.9 days (range 3-111 days).

A total of 618 organisms (bacterial and fungal) were isolated from the CAUTI cases. Amongst the bacterial pathogens, Gram-negative bacteria predominated. The predominant Gram-negative organisms were *Klebsiella* spp. [69 (11.2%)], *Pseudomonas aeruginosa* [50 (8.1%)], and *Escherichia coli* [45 (7.3%)]. *Acinetobacter baumannii complex* comprised 42 cases (6.8%). The predominant Gram-positive organisms were *Enterococcus* spp. [44 (7.1%)] and *Staphylococcus aureus* [23 (3.7%)]. The spectrum of organisms isolated from cases of CAUTI is summarized in Table 1.

Table 1. Spectrum of organisms from CAUTI cases.

Organisms (N = 618)	n (%)
Gram-negative bacteria (n = 330)	
Klebsiella pneumoniae	69 (11.17)
Pseudomonas aeruginosa	50 (8.09)
Escherichia coli	45 (7.28)
Acinetobacter baumannii	42 (6.80)
Enterobacter spp.	15 (2.43)
Proteus mirabilis	10 (1.62)
Providencia spp.	6 (0.97)
Others	93 (15.05)
Gram-positive bacteria (n = 67)	
Enterococcus spp.	44 (7.12)
Staphylococcus aureus	23 (3.72)
Fungi (n = 221)	
Candida spp.	221 (35.76)

Candida spp. comprised 35.8% (221) of the organisms in the CAUTI cases. The *Candida* CAUTI rate was 2.8/1,000 UCDs. The most common *Candida* species were *C. tropicalis* (n = 83, 37.5%), *C. albicans* (n = 63, 28.5%), *C. parapsilosis* (n = 41, 18.5%), *C. glabrata* (n = 17, 7.7%), *C. auris* (n = 6, 2.7%), and others (n = 11, 5%).

Relation between UCD and the development of CAUTI

Table 2 shows the relation between UCD and predisposition for the development of CAUTI. There was a highly significant relationship between UCD and the development of CAUTI. The patients having UCD > 10 had a significantly higher rate of CAUTI (10.58 /1,000 UCD) as compared to those with ≤ 10 days (3.87/1,000 UCD), the *p* of which was found to be < 0.00001(highly significant).

Type of injuries and CAUTI episodes

Head injury patients had the maximum number of episodes of CAUTI; 217 (37.6%), followed by polytrauma injuries; 172 (29.8%), orthopedic and spinal injuries; 165 (28.6%), and miscellaneous injuries; 23 (4%).

Table 2. Relation between urinary catheter days (UCD) and CAUTI episodes.

	Urinary Catheter Days			
	0-5	**6-10**	**11-14**	**≥ 15**
No. of patients	8,378	2,866	913	1,193
UCD	22,019	21,639	11,286	27,261
No. of episodes	45	124	122	286
CAUTI rate	2.04	5.73	10.80	10.49

Table 3. Episodes of CAUTI in each category of injuries with DUR and the average CAUTI rate.

	CAUTI	ICU Days	UCD	DUR	Rate
Head injuries	217	48,784	33,443	0.69	6.50
Orthopedic and Spine injuries	165	21,292	19,393	0.91	8.51
Polytrauma including abdominal and chest injuries	172	29,112	26,290	0.90	6.54
Miscellaneous	23	3,489	3,079	0.88	7.50
Total	**577**	**102,677**	**82,205**	**0.80**	**7.01**

Device utilization ratio (DUR)

The overall device utilization ratio was 80%. Orthopedic and spinal injuries had the highest DUR (91%), followed closely by polytrauma (90%), miscellaneous injuries (88%), and head injuries (69%). Although DUR and CAUTI rates were the lowest in head injury patients, the CAUTI episodes were the highest.

Table 3 summarizes the type of injuries with CAUTI episodes, device utilization, and CAUTI rates.

Organisms and their antibiograms

Table 4 shows the antimicrobial susceptibility profile of the most commonly isolated organisms. Most of the genera showed high levels of multi-drug resistance (MDR). Colistin, Tigecycline, and Imipenem were the most effective antimicrobials for Gram-negative bacteria. Almost all isolates of *E. coli* were sensitive to Colistin and Tigecycline. More than 50% of these isolates were also sensitive to Imipenem. *Klebsiella* spp. showed similar patterns of susceptibility. Imipenem sensitivity was seen in a few isolates. *Acinetobacter* spp. isolates had the highest susceptibility to Colistin and Tigecycline. *Pseudomonas* spp. was most susceptible to Colistin, but only about 50% of the isolates showed sensitivity to the remaining antibiotics.

Enterococcus spp. and *Staphylococcus aureus* were the most predominant Gram-positive bacteria. For Gram-positive bacteria, Vancomycin, Teicoplanin, and Linezolid had the highest susceptibility.

Outcome analysis

A total of 2,086 (15.6%) patients had a fatal outcome. Of the 546 patients with 577 episodes of CAUTI, 137 had a fatal outcome, giving a crude mortality rate of 25.1%. This mortality cannot be attributed to CAUTI.

The outcomes (death, transfer from ICU, discharge from the hospital, and LAMA) against the antecedent trauma suffered by these 546 patients are summarized in Table 5. Fatal outcomes were found more in patients with polytrauma injury.

Figure 1. Trend of CAUTI rate and DUR over the years.

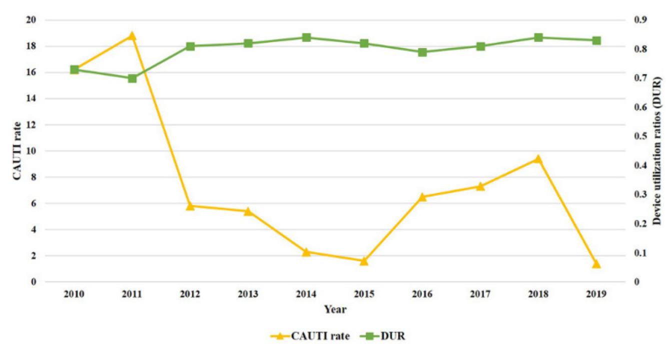

Table 4. Antibiotic susceptibility profile of the organisms.

	Gram-negative bacteria, n (%)						Gram-positive bacteria, n (%)	
	***Klebsiella* spp. (n = 69)**	***E. coli* (n = 45)**	***Enterobacter* spp. (n = 15)**	***Acinetobacter* spp. (n = 42)**	***Pseudomonas* spp. (n = 50)**		***Enterococcus* spp. (n = 44)**	***Staphylococcus* spp. (n = 23)**
Amikacin	16 (23.2)	35 (77.8)	11 (73.3)	8 (19.0)	24 (48.0)	Cefoxitin	**	8 (34.8)
Ciprofloxacin	3 (4.3)	3 (6.7)	9 (60.0)	1 (2.4)	21 (42.0)	Ciprofloxacin	5 (11.4)	1 (4.3)
Ceftazidime	4 (5.8)	13 (28.9)	7 (46.7)	1 (2.4)	23 (46.0)	Clindamycin	**	16 (69.6)
Imipenem	7 (10.1)	26 (57.8)	10 (66.7)	1 (2.4)	23 (46.0)	Linezolid	37 (84.1)	23 (100)
Tigecycline	45 (65.2)	44 (97.8)	13 (86.7)	33 (78.6)	1 (2.0)	Teicoplanin	29 (65.9)	23 (100)
Piperacillin	6 (8.7)	16 (35.6)	10 (66.7)	1 (2.4)	22 (44.0)	Vancomycin	28 (63.6)	23 (100)
Colistin	59 (85.5)	43 (95.6)	0 (00)	41 (97.6)	48 (96.0)			

Table 5. Type of injuries and outcome of patients with CAUTI.

	Head injuries	Orthopedic and Spine injuries	Polytrauma	Miscellaneous	Total
Discharged	18 (56.3)	9 (28.1)	5 (15.6)	0 (0.0)	32
Death	35 (25.5)	44 (32.1)	53 (38.7)	5 (3.6)	137
LAMA	2 (12.5)	1 (6.3)	0 (0.0)	13 (81.3)	16
Transfer	146 (40.4)	100 (27.7)	106 (29.4)	9 (2.5)	361
Total	**201 (36.8)**	**154 (28.2)**	**164**	**27 (4.9)**	**546**

Trend of CAUTI rate over the years

The trend analysis of the CAUTI rate over the years showed a decreasing trend. This is represented in Figure 1. However, the DUR was consistently elevated during the study period.

Discussion

Surveillance of HAIs using standard methodology is essential since it brings the data into the correct perspective. We used the same surveillance protocol during the entire study period, making the data comparable over time. The CAUTI rate of 7.4 /1000 catheter days in our study is higher than the reported rates of 2.4 and 5.5 per 1,000 catheter days set by CDC/NHSN and the International Nosocomial Infection Control Consortium (INICC), respectively [9,10]. It is also higher than the CAUTI rates of 6.5 and 4.1 per 1000 catheter days from the European CDC (ECDC) and the WHO high-resource countries [11]. However, this rate is lower than the 8.8/1000 catheter days from WHO low-resource countries. It is also lower than the CAUTI rate of 10.55/1000 catheter days from Trauma-ICU in 8 Asian countries, recently reported by the INICC [12].

When compared to other lower-middle-income countries, this rate is lower than 15.7/1000 catheter days reported from Mongolia [13], 8.99/1000 catheter days from Iran [14], and higher than 4.16 /1000 catheter days reported from Philippines [15]. However, most of the studies had a shorter period of surveillance.

Within India, the CAUTI rates are within the range of 2.1-11.3/1000 catheter days [16-21]. The surveillance settings in these studies catered to different sets of patients. Our centre is a trauma care facility; our focus was exclusively on trauma patients, and this is the most likely factor for the increased LOS of 19.9 days in patients with CAUTI as compared to previous publications [17,21]. Similar to our study, a high LOS was reported in patients with CAUTI from the trauma quality improvement program, the largest database of trauma patients in the United States [22].

We also found patients having UCD > 10 with significantly higher rates of CAUTI. This further reiterates the role of catheterization in the development of infections and the impact that catheter care or early catheter removal will have on CAUTI rate. Catheterization has been established to increase the risk of bacteriuria by 3-10% over each day of catheter use [23]. Short-term catheterization increases the risk of developing CAUTI by 80 %, while long-term catheterization by 100 % [24,25]. In our case, the nature of injuries for which these patients are admitted requires extensive use of devices for their management and recovery. Similar to previous work on CAUTI in trauma patients [26], head injury and polytrauma cases comprised the maximum of our CAUTI episodes. It has been reported that traumatic head and spine injuries increase the odds of CAUTI [27]. In our study, although the episodes of CAUTI were highest in head injury cases, the CAUTI rate and DUR were the lowest in them. This may be because there is a strict policy of removal of indwelling catheters in neurotrauma ICUs.

The LOS and DUR have been documented to play a significant role in CAUTI patients. We did not collect the patients' comorbidities; however, the above two factors are established as major determinants in the acquisition of CAUTI in a recently concluded study [12]. Female gender has also been reported as another risk factor [12]. This is different in our case, as most of our patients admitted with trauma were males.

The organism profile tilted toward Gram-negative organisms, with many being multi-drug resistant. The anti-microbial resistance level in all organisms, especially in *Acinetobacter* spp., is worrisome and is of great concern. Gram-positive organisms showed a similar trend of high anti-microbial resistance. The burden of *Candiduria* included in our study may have slightly inflated our CAUTI rate. It was, however, important to understand how much *Candida* spp. may affect trauma patients. This highlights the significant role of catheterization and the problem of *Candiduria*.

A few countries have also estimated the *Candiduria* burden at their hospital [28]. *Candida* comprised 35.8% of the total organisms in our study, lower than the 42.5% reported in Ethiopia. Only *Candida albicans* (2.6%) amongst *Candida* spp. were estimated in one center [21].

The crude mortality of 25.1 % reported in our study is more than those documented in previous publications [18,20,24,28]. Our rate is similar to the 25% reported from Mongolia [13]. Mortality is a consequence of many measured and unmeasured variables. We, therefore, do not attribute this mortality rate to CAUTI itself. However, the alarming MDR of the organism profile may negatively potentiate a fatal outcome as management becomes difficult. We are witnessing a silent pandemic of MDR. Therefore, mortality due to MDR infection has to be prevented.

Limitations

Our study has several limitations. Being a retrospective analysis, we could not incorporate the co-morbidity data of the patients. We also could not ascertain the attributable mortality and increased cost of treatment.

Conclusions

Surveillance of CAUTI with analysis of the organisms and AST profile will help improve infection prevention practices and management. The trends of the CAUTI rate and DUR will help establish guidelines in centers where long-term catheterization is necessary. Further, we need to incorporate Quality Improvement measures to prevent CAUTI occurrences in our center. These measures should be based on our data using the standard protocols of Quality Improvement and infection control. For managing multi-drug-resistant pathogens and infections, practices of cohort, isolation, and contact prevention would be useful.

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Conflict of interests

No conflict of interests is declared.

References

1. Dudeck MA, Horan TC, Peterson KD, Allen-Bridson K, Morrell G, Pollock DA, Edwards JR (2011) National Healthcare Safety Network (NHSN) Report, data summary for 2010, device-associated module. Am J Infect Control 39: 798-816. doi: 10.1016/j.ajic.2011.10.001.
2. Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, Lynfield R, Maloney M, McAllister-Hollod L, Nadle J, Ray SM (2014) Multistate point-prevalence survey of health care-associated infections. N Engl J Med 370:1198-208. doi: 10.1056/NEJMoa1306801.
3. Salgado CD, Karchmer TB, Farr BM (2003) Prevention of catheter-associated urinary tract infections. Prevention and Control of Nosocomial Infections 4th ed. Lippincott Williams & Wilkins, Philadelphia, PA: 4: 297-311.
4. Foxman B (2002) Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. Am J Med 113: 5-13. doi: 10.1016/s0002-9343(02)01054-9.
5. Burton DC, Edwards JR, Srinivasan A, Fridkin SK, Gould CV (2011) Trends in catheter-associated urinary tract infections in adult intensive care units—United States, 1990–2007. Infect Control Hosp Epidemiol 32: 748-756. doi: 10.1086/660872.
6. Mathur P (2008) Infections in traumatised patients: a growing medico-surgical concern. Indian J Med Microbiol 26: 212-216. doi: 10.4103/0255-0857.42030.
7. Horan TC, Andrus M, Dudeck MA (2008) CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 36: 309-332. doi: 10.1016/j.ajic.2008.03.002.
8. Collee JG, Mackie TJ, McCartney JE (1996) Mackie & McCartney practical medical microbiology. Fourteenth ed. New York: Churchill Livingstone.
9. Bagchi S, Watkins J, Norrick B, Scalise E, Pollock DA, Allen-Bridson K (2020) Accuracy of catheter-associated urinary tract infections reported to the National Healthcare Safety Network, January 2010 through July 2018. Am J Infect Control 48: 207-211. doi: 10.1016/j.ajic.2019.06.006.
10. Rosenthal VD, Maki DG, Mehta Y, Leblebicioglu H, Memish ZA, Al-Mousa HH, Balkhy H, Hu B, Alvarez-Moreno C, Medeiros EA, Apisarnthanarak A (2014) International Nosocomial Infection Control Consortiu (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. Am J Infect Control 42: 942-956. doi: 10.1016/j.ajic.2014.05.029.
11. El-Saed A, Balkhy HH, Weber DJ (2013) Benchmarking local healthcare-associated infections: available benchmarks and interpretation challenges. J Infect Public Health 6: 323-330. doi: 10.1016/j.jiph.2013.05.001.
12. Rosenthal VD, Yin R, Abbo LM, Lee BH, Rodrigues C, Myatra SN, Divatia JV, Kharbanda M, Nag B, Rajhans P, Shingte V (2024) An international prospective study of INICC analyzing the incidence and risk factors for catheter-associated urinary tract infections in 235 ICUs across 8 Asian Countries. Am J Infect Control 52: 54-60. doi: 10.1016/j.ajic.2023.07.007.
13. Ider BE, Baatar O, Rosenthal VD, Khuderchuluun C, Baasanjav B, Donkhim C, Batsuur B, Jambiimolom M, Purevdorj SE, Tsogtbaatar U, Sodnomdarjaa B (2016) Multicenter study of device-associated infection rates in hospitals of Mongolia: findings of the International Nosocomial Infection Control Consortium (INICC). Am J Infect Control 44: 327-31. doi: 10.1016/j.ajic.2015.10.010.
14. Jahani-Sherafat S, Razaghi M, Rosenthal VD, Tajeddin E, Seyedjavadi S, Rashidan M, Alebouyeh M, Rostampour M, Haghi A, Sayarbayat M, Farazmandian S (2015) Device-associated infection rates and bacterial resistance in six academic teaching hospitals of Iran: Findings from the International Nocosomial Infection Control Consortium (INICC). J Infect Public Health 8: 553-561. doi: 10.1016/j.jiph.2015.04.028.
15. Navoa-Ng JA, Berba R, Galapia YA, Rosenthal VD, Villanueva VD, Tolentino MC, Genuino GA, Consunji RJ, Mantaring III JB (2011) Device-associated infections rates in adult, pediatric, and neonatal intensive care units of hospitals in the Philippines: International Nosocomial Infection Control Consortium (INICC) findings. Am J Infect Control 39: 548-554. doi: 10.1016/j.ajic.2010.10.018.
16. Mathur P, Khurana S, Kumar S, Gupta D, Aggrawal R, Soni KD, Goyal K, Sokhal N, Singh GP, Bindra A, Sagar S (2021) Device associated infections at a trauma surgical center of India: Trend over eight years. Indian J Med Microbiol 39: 15-18. doi: 10.1016/j.ijmmb.2020.10.015.

17. Mehta Y, Jaggi N, Rosenthal VD, Kavathekar M, Sakle A, Munshi N, Chakravarthy M, Todi SK, Saini N, Rodrigues C, Varma K (2016) Device-associated infection rates in 20 cities of India, data summary for 2004–2013: findings of the International Nosocomial Infection Control Consortium. Infect Control Hosp Epidemiol 37: 172-181. doi: 10.1017/ice.2015.276.
18. Singh S, Chaturvedi R, Garg SM, Datta R, Kumar A (2013) Incidence of healthcare associated infection in the surgical ICU of a tertiary care hospital. Med J Armed Forces India 69: 124-129. doi: 10.1016/j.mjafi.2012.08.028.
19. Habibi S, Wig N, Agarwal S, Sharma SK, Lodha R, Pandey RM, Kapil A (2008) Epidemiology of nosocomial infections in medicine intensive care unit at a tertiary care hospital in northern India. Trop Doct 38: 233-235. doi: 10.1258/td.2008.070395.
20. Datta P, Rani H, Chauhan R, Gombar S, Chander J (2014) Health-care-associated infections: Risk factors and epidemiology from an intensive care unit in Northern India. Indian J Anaesth 58: 30-35.
21. Khan ID, Basu A, Kiran S, Trivedi S, Pandit P, Chattoraj A (2017) Device-associated healthcare-associated Infections (DA-HAI) and the caveat of multi-resistance in a multidisciplinary intensive care unit. Med J Armed Forces India 73: 222-231. doi: 10.1016/j.mjafi.2016.10.008.
22. Ladhani HA, Tseng ES, Claridge JA, Towe CW, Ho VP (2020) Catheter-associated urinary tract infections among trauma patients: poor quality of care or marker of effective rescue?. Surg Infect (Larchmt) 21: 752-759. doi: 10.1089/sur.2019.211.
23. Nicolle LE (2012) Urinary catheter-associated infections. Infect Dis Clin North Am 26: 13-27.
24. Parker D, Callan L, Harwood J, Thompson DL, Wilde M, Gray M (2009) Nursing interventions to reduce the risk of catheter-associated urinary tract infection: Part 1: Catheter selection. J Wound Ostomy Continence Nurs 36: 23-34. doi: 10.1097/01.WON.0000345173.05376.3e.
25. Maki DG, Tambyah PA (2001) Engineering out the risk for infection with urinary catheters. Emerg Infect Dis 7: 342. doi: 10.3201/eid0702.010240.
26. Bottiggi AJ, White KD, Bernard AC, Davenport DL (2015) Impact of device-associated infection on trauma patient outcomes at a major trauma center. Surg Infect 16: 276-80.
27. D'Hondt F, Everaert K (2011) Urinary tract infections in patients with spinal cord injuries. Curr Infect Dis Rep 13: 544-551. doi: 10.1007/s11908-011-0208-6.
28. Bizuayehu H, Bitew A, Abdeta A, Ebrahim S (2022) Catheter-associated urinary tract infections in adult intensive care units at a selected tertiary hospital, Addis Ababa, Ethiopia. Plos one 17: e0265102. doi: 10.1371/journal.pone.0265102.