ORIGINAL ARTICLE

Oman Medical Journal [2023], Vol. 38, No. 6: e571

Prospective Cohort Study of Incidence and Risk Factors for Catheter-associated Urinary Tract Infections in 212 Intensive Care Units of Nine Middle Eastern Countries

Zhilin Jin[1], Ruijie Yin[1], Eric Christopher Brown[1], Bhavarth Shukla[2], Brandon Hochahn Lee[3], Safaa Abdulaziz-Alkhawaja[4], Tahera Anwar Magray[4], Hala Mounir Agha[5], Amal El-Sisi[5], Amani Ali El-Kholy[6], Victor Bayani[6], Mohammad Abdellatif Daboor[7], Majeda Afeef Al- Ruzzieh[7], Ertugrul Guclu[8], Esra Olmez-Gazioglu[8], Oguz Dursun[9], Tuğçe Tural Kara[9], Iftihar Koksal[10], Ahmet Eroglu[10], Merve Havan[11], Tanıl Kendirli[11], Suna Secil Ozturk Deniz[12], Gizem Aktas[12], Dincer Yildizdas[13], Ozden Ozgur Horoz[13], Emel Okulu[14], Yasemin Ezgi Kostekci[14], Abeer Aly Omar[15], Ziad A. Memish[16] and Victor Daniel Rosenthal[1,17]*

[1]Department of Public Health Sciences, University of Miami Miller School of Medicine, Miami, USA
[2]Department of Medicine, University of Miami Miller School of Medicine, Miami, USA
[3]University of Miami, Miller School of Medicine. Miami, USA
[4]Department of Critical Care, Salmaniya Medical Center, Manama, Bahrain
[5]Department of Critical Care, Cairo University Specialized Pediatric Hospital, Cairo, Egypt
[6]Department of Critical Care, Dar Alfouad Hospital, [6]th of October City, Egypt
[7]Department of Critical Care, King Hussein Cancer Center, Amman, Jordan
[8]Department of Critical Care, Sakarya University Training and Research Hospital, Sakarya, Turkey
[9]Department of Critical Care, Akdeniz University Medical School, Antalya, Turkey
[10]Department of Critical Care, Karadeniz Technical University School of Medicine, Trabzon, Turkey
[11]Department of Critical Care, Ankara University Faculty of Medicine, Ankara, Turkey
[12]Department of Critical Care, Pamukkale University Hospital, Denizli, Turkey
[13]Department of Critical Care, Balcali Hospital Pediatric Intensive Care Unit, Adana, Turkey
[14]Neonatal Intensive Care Unit, Children's Hospital, Ankara University Faculty of Medicine, Ankara, Turkey
[15]Infection Control Directorate, Ministry of Health, Kuwait City, Kuwait
[16]Department of Infection Control, King Saud Medical City, Ministry of Health, Riyadh, Saudi Arabia
[17]International Nosocomial Infection Control Consortium Foundation, Miami, USA

ARTICLE INFO

Article history:
Received: 11 May 2023
Accepted: 2 July 2023

Online:
DOI 10.5001/omj.2023.121

Keywords:
Urinary Tract Infections; Risk Factors; Intensive Care; Incidence; Middle East.

ABSTRACT

Objectives: To identify urinary catheter (UC)-associated urinary tract infections (CAUTI) incidence and risk factors (RF) in nine Middle Eastern countries. ***Methods***: We conducted a prospective cohort study between 1 January 2014 and 2 December 2022 in 212 intensive care units (ICUs) of 67 hospitals in 38 cities in nine Middle Eastern countries (Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Saudi Arabia, Turkey, and the UAE). To estimate CAUTI incidence, we used the number of UC days as denominator and the number of CAUTIs as numerator. To estimate CAUTI RFs, we analyzed the following 10 variables using multiple logistic regression: patient sex, age, length of stay (LOS) before CAUTI acquisition, UC-days before CAUTI acquisition, UC-device utilization (DU) ratio, hospitalization type, ICU type, facility-ownership, country income level classified by World Bank, and time period. ***Results:*** Among 50 637 patients hospitalized for 434 523 patient days, there were 580 cases of acquired CAUTIs. The pooled CAUTI rate per 1000 UC days was 1.84. The following variables were independently associated with CAUTI: age, rising risk 1.0% yearly (adjusted odds ratio [aOR] = 1.01, 95% CI: 1.01–1.02; $p <$ 0.0001); female sex (aOR = 1.31, 95% CI: 1.09–1.56; $p <$ 0.0001); LOS before CAUTI acquisition, rising risk 6.0% daily (aOR = 1.06, 95% CI: 1.05–1.06; $p <$ 0.0001); and UC/DU ratio (aOR = 1.11, 95% CI: 1.06–1.14; $p <$ 0.0001). Patients from lower-middle-income countries (aOR = 4.11, 95% CI: 2.49–6.76; $p <$ 0.0001) had a similar CAUTI risk to the upper-middle countries (aOR = 3.75, 95% CI: 1.83–7.68; $p <$ 0.0001). The type of ICU with the highest risk for CAUTI was neurologic ICU (aOR = 27.35, 95% CI: 23.03–33.12; $p <$ 0.0001), followed by medical ICU (aOR = 6.18, 95% CI: 2.07–18.53; p < 0.0001) when compared to cardiothoracic ICU. The periods 2014–2016 (aOR = 7.36, 95% CI: 5.48–23.96; $p <$ 0.001) and 2017–2019 (aOR = 1.15, 95% CI: 3.46–15.61; $p <$ 0.001) had a similar risk to each other, but a higher risk compared to 2020–2022.

*Corresponding author: ✉victor_rosenthal@inicc.org

Conclusions: The following CAUTI RFs are unlikely to change: age, sex, ICU type, and country income level. Based on these findings, it is suggested to focus on reducing LOS, UC/DU ratio, and implementing evidence-based CAUTI prevention recommendations.

Low- and middle-income countries (LMICs) are known to have higher rates of catheter-associated urinary tract infections (CAUTIs) than high-income nations.[1,2] The International Nosocomial Infection Control Consortium (INICC) estimated 3.16 CAUTIs for every 1000 urinary catheter (UC)-days in LMICs.[2] In the USA, the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) reported 1.3 CAUTIs per 1000 urinary catheter (UC)-days.[3]

CAUTI is an independent, significant risk factor (RF) for mortality in the intensive care unit (ICU).[3–5] According to an investigation, mortality rates for ICU patients without any healthcare-associated infections (HAIs) are 17.1%, CAUTI mortality rates are 30.15%, and CAUTI combined with central line-associated bloodstream infections and ventilator-associated pneumonia results in a mortality rate of 63.4%.[2] Twenty-eight community hospitals in the Southeast of the USA were found to have a median yearly cost of HAIs per facility of USD 594 683, with CAUTIs accounting for a mean of USD 758 per infection.[6]

Other studies identified the following variables as CAUTI RFs: female sex,[7] age > 60,[8] length of catheterization,[9,10] and poor hygiene.[11] A recent Tanzanian study found outpatient settings to carry higher risk for CAUTI than inpatient settings. Individual RFs for those outpatients included older age, level of education, and duration of the catheter.[12] A Saudi Arabian study with 81 CAUTI patients found type-O blood type to be a protective factor for CAUTI.[13]

Nevertheless, no study has simultaneously looked at many Middle Eastern nations to estimate the prevalence of CAUTI RFs in ICUs. In addition, no prospective study has been conducted over eight years. Additionally, no study has examined simultaneously the relationships between the 10 variables listed below and their association with CAUTI: (1) age, (2) sex, (3) length of stay (LOS) before CAUTI acquisition, (4) UC-days before CAUTI acquisition, (5) UC-device utilization (DU) ratio as a marker of patient illness severity, (6) hospitalization type, (7) ICU type, (8) facility ownership, (9) income level of the country according to world bank, and (10) time period. The objectives of this study were to provide CAUTI rates stratified by various variables and determine whether the aforementioned 10 variables are CAUTI RFs.

METHODS

Between 1 January 2014 and 12 February 2022, patients admitted to 212 ICUs at 67 hospitals spread across 38 cities in nine Middle Eastern nations (Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Saudi Arabia, Turkey, and the UAE) participated in this multinational, multi-center, cohort prospective study.

We used the INICC Surveillance Online System (ISOS), an online platform that incorporates CDC/NHSN standards and procedures.[14] ISOS gathers patient-specific data on all patients, with and without CAUTI.[15] Data from all patients admitted to the ICU allow matching by multiple variables to determine CAUTI RFs.

Data for each patient were gathered at the time of ICU admission. From the moment of admission till discharge, infection prevention professionals (IPPs) visited each ICU patient every day and uploaded the patient data to ISOS.[15]

In addition to patient information, such as sex, age, hospitalization type, and the use of invasive devices, the information provided at the time of patient admission included location-specific information including the setting, country, city, admission date, and ICU type. IPPs uploaded data about the patient's invasive devices and positive cultures up until the patient was discharged. A specialist in infectious diseases investigated the patients for HAI. The ISOS instantly shows an alert and refers the IPP to an online module where they may check all the CDC NHSN criteria to validate the existence and type of HAI when IPPs upload the results of the culture to the system.[15] The Institutional Review Board of the participating hospitals approved this study. The patients' and hospital's names were kept anonymous.

We adopted the CDC's definitions of HAI (1991) with all their subsequent updates through 2022.[14] The updated CDC definitions of HAIs were used by all IPPs of all participant hospitals over the eight years of this study.[14] The key definitions are listed below.

CUTI: a UTI where an indwelling UC was in place for more than two consecutive days in an inpatient location on the date of the event, with the day of device placement being day 1, and an indwelling UC was in place on the date of the event or the day before. If an indwelling UC was in place for more than two consecutive days in an inpatient location and then removed, the date of event for the UTI must be the day of device discontinuation or the next day for the UTI to be catheter-associated.[14]

Indwelling UC: a drainage tube that is inserted into the urinary bladder through the urethra is left in place and connected to a drainage bag (including leg bags). Indwelling UCs used for intermittent or continuous irrigation are also included in CAUTI surveillance.[14]

UC/DU ratio: UC/DU is the ratio of UC days to patient days for each location type. As such, the UC/DU of a location measures the use of invasive devices and constitutes an extrinsic CAUTI RF. UC/DU ratio also serves as a marker for the severity of illness which is an intrinsic RF for HAI.[14]

Types of healthcare facilities: (a) publicly owned: owned or controlled by a public corporation or a governmental body, where control is the capacity to decide on the corporate strategy; (b) not-for-profit privately owned: legal or social organizations established for the exclusive goal of creating goods and services, whose legal position prohibits them from serving as a source of revenue, profit, or other financial gains for the unit(s) that established, controlled, or financed them; and (c) for-profit privately owned: healthcare facilities created to produce goods and services with potential to bring in financial gains for owners.[16]

To estimate rates of CAUTI per 1000 UC days, we divided the number of CAUTIs by the number of UC days and multiplied the result by 1000.

To estimate CAUTI RFs using multiple logistic regression, patients with and without CAUTI were compared. We analyzed the following 10 variables and their association with the outcome (CAUTI): age; sex; LOS before CAUTI acquisition; UC-days before CAUTI acquisition; UC/DU ratio as a marker of severity of illness of patient; hospitalization type (medical and surgical); ICU type (cardio-thoracic, neurologic, neuro-surgical, adult-oncology, medical, medical-surgical, pediatric, respiratory, surgical, trauma, coronary, and pediatric-oncology); facility ownership (publicly owned, not-for-profit privately owned, for-profit privately owned, and teaching hospitals);[16] and time period (period 1: 1998–2001, period 2: 2002–2005, period 3: 2006–2009, period 4: 2010–2013, period 5: 2014–2017, and period 6: 2018–2022). We did not analyze the impact of the type of UC used because the use of suprapubic catheters was < 1%, showing a lack of balance with indwelling catheters. The evaluated outcome was the acquisition of CAUTI according to CDC/NHSN definitions.[14]

Statistically significant variables were independently associated with an increased risk for CAUTI. The Wald test was employed as the test statistic, and a two-sided 0.05 type I error rate was chosen as the level of statistical significance. The adjusted odds ratios (aORs) and associated 95% CIs for statistically significant factors were calculated from the results of multiple logistic regression. All statistical analyses were performed using R Software version 4.1.3, Tidymodels (https://cran.r-project.org/).

RESULTS

This international, multicenter, cohort, prospective surveillance study of CAUTIs was carried out in 212 ICUs of 67 hospitals in 38 cities, across nine Middle Eastern nations participating in INICC from 1 January 2014 to 12 February 2022.

A total of 580 cases of CAUTI were identified among 50 637 patients across 434 523 patient days. Data on the setting and the patient are presented in Table 1. Table 2 displays the stratified CAUTI rate by ICU type, facility ownership type, country economic level as determined by the World Bank, and UC type.

Using multiple logistic regression, the following variables were identified as significantly associated with CAUTI [Table 3]: age, rising risk 1.0% yearly (aOR = 1.01, 95% CI: 1.01–1.02; $p < 0.001$); female sex (aOR = 1.31, 95% CI: 1.09–1.56; $p < 0.001$); LOS before CAUTI acquisition, rising risk 6.0%

Table 1: Study setting and patient characteristics.

Patient characteristics	Values
Total patients, N	50 637
Total patients days	434 523
Average length of stay, days	8.5 ± 11.4
Sex, n (%)	
Male	41 261 (81.5)
Female	9376 (18.5)
Age, years	43.3 ± 27.5
Survival status, n (%)	
Alive	41 261 (81.5)
Died	9376 (18.5)
Number of patients per hospitalization type, n (%)	
Medical hospitalization	37 889 (74.8)
Surgical hospitalization	12 748 (25.2)
Catheter-associated urinary tract infections, n	580
Invasive device utilization	
UC-utilization ratio	0.6 ± 0.7
Total UC days	293 970
Mean UC days	5.9 ± 9.8
Number of UC days per type of UC, n (%)	
Indwelling catheter	292 915 (99.6)
Suprapubic catheter	1055 (0.4)
Setting characteristics, n	
Hospitals	67
Cities	38
Countries	9
ICUs	212
Number of patients admitted per type of ICU, n (%)	
Medical-surgical ICU	29 807 (58.9)
Pediatric ICU	4508 (8.9)
Cardio-thoracic ICU	2371 (4.7)
Coronary ICU	3741 (7.4)
Medical ICU	3593 (7.1)
Neuro-surgical ICU	86 (0.2)
Neurologic ICU	185 (0.3)
Adult-oncology ICU	3131 (6.2)
Pediatric-oncology ICU	1463 (2.9)
Respiratory ICU	44 (0.1)
Surgical ICU	1665 (3.3)
Trauma ICU	43 (0.1)
Number of countries, stratified per income level according to World Bank, n (%)	
Lower middle-income country	2 (22.2)
Upper middle-income country	3 (33.3)
High-income country	4 (44.4)
Number of patients admitted per facility ownership, n (%)	
Publicly owned facilities	30 250 (59.7)
For-profit privately owned facilities	8193 (16.2)
Teaching hospitals	12 194 (24.1)

UC: urinary catheter; ICU: intensive care unit.

daily (aOR = 1.06, 95% CI: 1.05–1.06; $p < 0.001$); and UC/DU ratio (aOR = 1.11, 95% CI: 1.06–1.14; $p < 0.001$). Lower-middle income countries (aOR = 4.11, 95% CI: 2.49–6.76; $p < 0.001$) had a similar risk to upper-middle countries (aOR = 3.75, 95% CI: 1.83–7.68; $p < 0.001$), but both were higher RFs compared to high-income countries. The ICU with the highest risk for CAUTI was neurologic ICU (aOR = 27.35, 95% CI: 23.03–33.12; $p < 0.001$), followed by medical ICU (aOR = 6.18, 95% CI: 2.07–18.53; $p < 0.001$) when compared to cardiothoracic ICU. The period 2014–2016 (aOR = 7.36, 95% CI: 5.48–23.96; $p < 0.001$) and the period 2017–2019 (aOR = 1.15, 95% CI: 3.46–15.61; $p < 0.001$) had a similar risk to each other, but a higher risk when compared to the time period 2020–2022.

The pooled CAUTI rate per 1000 UC days was 1.84. Age, sex, LOS, UC/DU ratio, lower- and upper-middle income countries, neurologic ICU, and time periods 1 and 2 were associated with the highest risks for CAUTI. After adjusting all confounders in this study, surgical hospitalization and facility ownership were not associated with CAUTI risk.

DISCUSSION

Pooled rates of CAUTI in our study conducted in ICUs were lower than the pooled CAUTI rates reported by INICC.[2] CAUTI rate in ICUs of LMICs was 3.16 CAUTIs per 1000 UC days per the last INICC report.[2] However, pooled rates of CAUTI in our present study were higher than those of ICUs of the CDC/NHSN report, 1.3 CAUTI per 1000 UC days.[3] According to our study, the CAUTI rate at ICUs in lower-middle-income countries in the Middle East was 2.75 per 1000 UC days; the CAUTI rate at ICUs in upper-middle-income countries was 2.47 per 1000 UC days; and the CAUTI rate at ICUs in high-income countries was 1.64 per 1000 UC days. The highest CAUTI rate was in the lower-middle-income countries, and the lowest was in the high-income countries. This was consistent with previous studies comparing CAUTI rates in ICUs of LMICs with CAUTI rates in ICUs of high-income countries.[17]

In the present study, female sex was a significant RF for CAUTI. Similarly, in an urban academic health system of over 2500 beds, encompassing two large academic medical centers, two community hospitals, and a pediatric hospital, Letica-Kriegel et

Table 2: Catheter-associated urinary tract infection (CAUTI) rates stratified per ICU type, facility ownership type, and urinary catheter type.

Variables	Patients, n	Patient days, n	UC days, n	CAUTIs, n	CAUTI rate[a]	95% CI
ICU type[b]						
Neuro-surgical	86	1487	937	6	6.41	6.24–6.57
Neurologic	185	2111	1980	11	5.55	5.45–5.66
Respiratory	44	573	366	2	5.46	5.22–5.71
Coronary	3741	22 355	5438	23	4.22	4.17–4.28
Medical	3593	32 515	21 909	79	3.61	3.58–3.63
Trauma	43	593	327	1	3.05	2.87–3.25
Surgical	1665	15 819	10 165	31	3.04	3.01–3.08
Pediatric	4508	39 418	12 278	32	2.61	2.57–2.64
Adult-oncology	3131	15 290	13 652	34	2.49	2.46–2.52
Medical-surgical	29 807	276 599	220 718	354	1.61	1.59–1.62
Cardio-thoracic	2371	19 079	7761	6	0.77	0.75–0.79
Pediatric-oncology	1463	8684	4277	1	0.23	0.21–0.25
Lower-middle income						
Pooled	4941	44 030	19 263	53	2.75	2.72–2.77
Publicly owned facilities	190	1387	983	0	0.00	NA
For-profit privately owned facilities	1065	6471	4300	39	9.06	8.98–9.16
Teaching hospitals	3686	36 172	13 980	14	1.01	0.98–1.02
Upper-middle income						
Pooled	13 164	98 630	78 046	193	2.47	2.46–2.48
Publicly owned facilities	25	463	188	2	10.64	10.17–11.12
For-profit privately owned facilities	4631	25 166	18 002	35	1.94	1.92–1.97
Teaching hospitals	8508	73 001	59 856	156	2.61	2.59–2.62
High income						
Pooled	32 532	291 863	202 499	334	1.64	1.64–1.67
Publicly owned facilities	30 035	269 958	188 224	324	1.72	1.71–1.73
For-profit privately owned facilities	2497	21 905	14 275	10	0.71	0.68–0.72
Urinary catheter type (pooled)	36 021	345 316	293 970	543	1.84	1.83–1.85
Indwelling catheter	35 903	344 086	292 915	541	1.85	1.84–1.86
Suprapubic catheter	118	1230	1055	2	1.89	1.81–1.98

ICU: intensive care unit; UC: urinary catheter.
[a]Rate of CAUTI per 1000 urinary catheter-days.
[b]ICUs are listed in order of the highest to lowest CAUTIs rate.

al,[18] found that being female statistically increased the chances of acquiring CAUTI.

The LOS before the acquisition of CAUTI was associated with 6.0% daily increase in the risk of CAUTI. A study conducted in cardiac surgical patients by Gillen et al,[19] similarly showed the role of LOS before CAUTI acquisition as a significant RF for CAUTI through both univariate and multivariate analyses.

We found that the UC/DU ratio was associated with the risk for CAUTI. Likewise stated by Meddings et al,[20] utilization of UCs, such as unnecessary placement and prolonged usage, are large RFs for acquiring a CAUTI. Their results showed that using a reminder or a stop order was able to reduce CAUTI rate by 52%.

We discovered that the risk for CAUTI was decreasing over our eight-year-long period of the study, which is consistent with recent improvements in infection prevention techniques. To avoid this particular bias and also to adjust to changes in infection prevention and control practices, we adjusted our analysis to the time period.

We identified a similar CAUTI rate in those patients using an indwelling catheter compared with those using a suprapubic catheter. This is consistent with the study of Baan et al,[21] which found a similar CAUTI rate comparing both catheter types. We

Table 3: Multiple logistic regression analysis of risk factors for catheter-associated urinary tract infections.

Variables	aOR	95% CI	*p*-value
Age	1.01	1.01–1.02	< 0.001
Sex, female	1.31	1.09–1.56	< 0.001
Length of stay	1.06	1.05–1.06	< 0.001
UC days	0.97	0.97–0.99	< 0.001
UC/DU ratio	1.11	1.06–1.14	< 0.001
Surgical hospitalization	1.04	0.83–1.32	0.730
Reference: lack of use of UC			
Indwelling catheter	7.23	4.81–10.87	< 0.001
Suprapubic catheter	5.45	0.98–30.27	0.060
Reference: for-profit privately owned facilities			
Publicly owned facilities	1.48	0.97–2.27	0.070
Teaching hospitals	0.56	0.29–1.07	0.080
Reference: cardiothoracic			
Neurologic ICU	27.35	23.03–33.12	< 0.001
Medical ICU	6.18	2.07–18.53	< 0.001
Pediatric ICU	5.83	1.83–18.53	< 0.001
Coronary ICU	5.44	1.64–18.03	< 0.001
Surgical ICU	4.83	1.58–14.79	< 0.001
Medical-surgical ICU	4.02	1.34–12.07	< 0.001
Adult-oncology ICU	3.42	0.74–15.78	0.120
Pediatric-oncology ICU	0.36	0.03–4.25	0.410
Reference: high-income country			
Lower-middle income country	4.11	2.49–6.76	< 0.001
Upper-middle income country	3.75	1.83–7.68	< 0.001
Reference: time period 3 (2020–2022)			
Time period 1 (2014–2016)	7.36	5.48–23.96	< 0.001
Time period 2 (2017–2019)	1.15	3.46–15.61	< 0.001

UC: urinary catheter; DU: device utilization; ICU: intensive care unit; aOR: adjusted odds ratio.

identified a higher risk for CAUTI in patients using an indwelling catheter compared with those using a suprapubic catheter. This is inconsistent with the study of Han et al,[22] who found that indwelling catheterization was not associated with an increased urinary tract infection risk compared to suprapubic tubes and intermittent catheterization if the catheterization duration was for ≤ 5 days. However, a suprapubic tube or intermittent catheterization was associated with a lower rate of urinary tract infection in the case of longer-term catheterization in the postoperative period.

Some of the CAUTI RFs identified in our study were unlikely to be amenable to change, such as age, sex, ICU type, and country income level. However, some others can be improved; for example, LOS before the acquisition of a CAUTI, UC/DU ratio and neurologic ICUs. Based on our findings, it is suggested that we focus on strategies to reduce the UC/DU ratio, reduce LOS, and implement an evidence-based set of CAUTI prevention recommendations, such as those published by the Healthcare Infection Control Practices Advisory Committee.[23] In addition, the high rate of CAUTI prevalent in the Middle East[1,2,24,25] can be reduced by utilizing a strategy of monitoring compliance with recommendations and providing performance feedback to healthcare personnel, as demonstrated in several low- and medium-income countries.[24–29]

Our research has some limitations. Firstly, because this study is a part of a surveillance system in which hospitals voluntarily engage at no cost, it is not representative of all hospitals in the Middle East. Secondly, the CAUTI rates in our research are probably lower than the overall rates in the region because the hospitals that volunteered to participate in our surveillance system are most likely to have higher-quality CAUTI surveillance and prevention programs. Thirdly, the proportion of suprapubic catheters used was significantly lower than that of indwelling catheters and for that reason, we did not analyze the impact of this variable. Lastly, we used the UC/DU ratio as a marker for the severity of patients' illnesses rather than the severity of illness scores that were gathered by the IPPs of the collaborating hospitals.

CONCLUSION

Our study identified several independent RFs for CAUTI in ICUs, mainly age, female sex, LOS, UC/DU ratio, neurologic ICU, and the country's income level. Some of these RFs have been identified in previous studies, further validating our results. Our findings have important implications for CAUTI prevention, including reducing the LOS and UC/DU ratio and implementing evidence-based prevention recommendations.

Disclosure

The authors declared no conflicts of interest. No funding was received for this study.

REFERENCES

1. Rosenthal VD, Maki DG, Salomao R, Moreno CA, Mehta Y, Higuera F, et al; International Nosocomial Infection Control Consortium. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann Intern Med 2006 Oct;145(8):582-591.
2. Rosenthal VD, Duszynska W, Ider BE, Gurskis V, Al-Ruzzieh MA, Myatra SN, et al. International nosocomial infection control consortium (INICC) report, data summary of 45 countries for 2013-2018, adult and pediatric units, device-associated module. Am J Infect Control 2021 Oct;49(10):1267-1274.
3. Rosenthal VD, Yin R, Lu Y, Rodrigues C, Myatra SN, Kharbanda M, et al. The impact of healthcare-associated infections on mortality in ICU: a prospective study in Asia, Africa, Eastern Europe, Latin America, and the Middle East. Am J Infect Control 2023 Jun;51(6):675-682.
4. Rosenthal VD, Jin Z, Rodrigues C, Myatra SN, Divatia JV, Biswas SK, et al. Risk factors for mortality over 18 years in 317 ICUs in 9 Asian countries: the impact of healthcare-associated infections. Infect Control Hosp Epidemiol 2022 Oct;(Oct):1-6.
5. Rosenthal VD, Yin R, Valderrama-Beltran SL, Gualtero SM, Linares CY, Aguirre-Avalos G, et al. Multinational prospective cohort study of mortality risk factors in 198 ICUs of 12 Latin American countries over 24 years: the effects of healthcare-associated infections. J Epidemiol Glob Health 2022 Dec;12(4):504-515.
6. Anderson DJ, Kirkland KB, Kaye KS, Thacker PA II, Kanafani ZA, Auten G, et al. Underresourced hospital infection control and prevention programs: penny wise, pound foolish? Infect Control Hosp Epidemiol 2007 Jul;28(7):767-773.
7. Feng YH, Lu CY. [Factors associated with catheter-associated urinary tract infection in patients in the intensive care unit]. Hu Li Za Zhi 2022 Dec;69(6):56-64.
8. Liu Y, Li Y, Huang Y, Zhang J, Ding J, Zeng Q, et al. Prediction of catheter-associated urinary tract infections among neurosurgical intensive care patients: a decision tree analysis. World Neurosurg 2023 Feb;170:123-132.
9. Baker S, Shiner D, Stupak J, Cohen V, Stoner A. Reduction of catheter-associated urinary tract infections: a multidisciplinary approach to driving change. Crit Care Nurs Q 2022 Oct-Dec;45(4):290-299.
10. Gad MH, AbdelAziz HH; Catheter-Associated Urinary Tract Infections in the Adult Patient Group. Catheter-associated urinary tract infections in the adult patient group: a qualitative systematic review on the adopted preventative and interventional protocols from the literature. Cureus 2021 Jul;13(7):e16284.
11. Rubi H, Mudey G, Kunjalwar R. Catheter-associated urinary tract infection (CAUTI). Cureus 2022 Oct;14(10):e30385.
12. Ndomba AL, Laisser RM, Silago V, Kidenya BR, Mwanga J, Seni J, et al. Urinary tract infections and associated factors among patients with indwelling urinary catheters attending Buganda medical centre a tertiary hospital in northwestern Tanzania. Microorganisms 2022 Feb;10(2):473.
13. Sulaiman KA, Al Qahtani N, Al Muqrin M, Al Dossari M, Al Wabel A, Al Sulaiman T, et al. The correlation between non-O blood group type and recurrent catheter-associated urinary tract infections in critically ill patients: a retrospective study. J Int Med Res 2022 Jul;50(7):3000605221108082.
14. Dudeck MA, Edwards JR, Allen-Bridson K, Gross C, Malpiedi PJ, Peterson KD, et al. National healthcare safety network report, data summary for 2013, device-associated module. Am J Infect Control 2015 Mar;43(3):206-221.
15. Rosenthal VD. International Nosocomial Infection Control Consortium (INICC) resources: INICC multidimensional approach and INICC surveillance online system. Am J Infect Control 2016 Jun;44(6):e81-e90.
16. World Health Organization. Glossary of terms: WHO European primary health care impact performance and capacity tool (PHC-IMPACT). 2019 [cited 2022 August 23]. Available from: https://www.euro.who.int/__data/assets/pdf_file/0006/421944/Glossary-web-171219.pdf.
17. Rosenthal VD, Jarvis WR, Jamulitrat S, Silva CP, Ramachandran B, Dueñas L, et al; International Nosocomial Infection Control Members. Socioeconomic impact on device-associated infections in pediatric intensive care units of 16 limited-resource countries: international Nosocomial Infection Control Consortium findings. Pediatr Crit Care Med 2012 Jul;13(4):399-406.
18. Letica-Kriegel AS, Salmasian H, Vawdrey DK, Youngerman BE, Green RA, Furuya EY, et al. Identifying the risk factors for catheter-associated urinary tract infections: a large cross-sectional study of six hospitals. BMJ Open 2019 Feb;9(2):e022137.
19. Gillen JR, Isbell JM, Michaels AD, Lau CL, Sawyer RG. Risk factors for urinary tract infections in cardiac surgical patients. Surg Infect (Larchmt) 2015 Oct;16(5):504-508.
20. Meddings J, Rogers MA, Macy M, Saint S. Systematic review and meta-analysis: reminder systems to reduce catheter-associated urinary tract infections and urinary catheter use in hospitalized patients. Clin Infect Dis 2010 Sep;51(5):550-560.
21. Baan AH, Vermeulen H, van der Meulen J, Bossuyt P, Olszyna D, Gouma DJ. The effect of suprapubic catheterization versus transurethral catheterization after abdominal surgery on urinary tract infection: a randomized controlled trial. Dig Surg 2003;20(4):290-295.

22. Han CS, Kim S, Radadia KD, Zhao PT, Elsamra SE, Olweny EO, et al. Comparison of urinary tract infection rates associated with transurethral catheterization, suprapubic tube and clean intermittent catheterization in the postoperative setting: a network meta-analysis. J Urol 2017 Dec;198(6):1353-1358.
23. Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA; Healthcare Infection Control Practices Advisory Committee. Guideline for prevention of catheter-associated urinary tract infections 2009. Infect Control Hosp Epidemiol 2010 Apr;31(4):319-326.
24. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. Infect Control Hosp Epidemiol 2004 Jan;25(1):47-50.
25. Navoa-Ng JA, Berba R, Rosenthal VD, Villanueva VD, Tolentino MC, Genuino GA, et al. Impact of an International Nosocomial Infection Control Consortium multidimensional approach on catheter-associated urinary tract infections in adult intensive care units in the Philippines: International Nosocomial Infection Control Consortium (INICC) findings. J Infect Public Health 2013 Oct;6(5):389-399.
26. Rosenthal VD, Ramachandran B, Villamil-Gómez W, Armas-Ruiz A, Navoa-Ng JA, Matta-Cortés L, et al. Impact of a multidimensional infection control strategy on central line-associated bloodstream infection rates in pediatric intensive care units of five developing countries: findings of the International Nosocomial Infection Control Consortium (INICC). Infection 2012 Aug;40(4):415-423.
27. Leblebicioglu H, Ersoz G, Rosenthal VD, Yalcin AN, Akan OA, Sirmatel F, et al. Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in adult intensive care units in 10 cities of Turkey: International Nosocomial Infection Control Consortium findings (INICC). Am J Infect Control 2013 Oct;41(10):885-891.
28. Kanj SS, Zahreddine N, Rosenthal VD, Alamuddin L, Kanafani Z, Molaeb B. Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in an adult intensive care unit in Lebanon: International Nosocomial Infection Control Consortium (INICC) findings. Int J Infect Dis 2013 Sep;17(9):e686-e690.
29. Rosenthal VD, Ramachandran B, Dueñas L, Alvarez-Moreno C, Navoa-Ng JA, Armas-Ruiz A, et al. Findings of the International Nosocomial Infection Control Consortium (INICC), Part I: Effectiveness of a multidimensional infection control approach on catheter-associated urinary tract infection rates in pediatric intensive care units of 6 developing countries. Infect Control Hosp Epidemiol 2012 Jul;33(7):696-703.