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Original Article

Incidence and risk factors for catheter-associated urinary tract infection in 623 intensive care units throughout 37 Asian, African, Eastern European, Latin American, and Middle Eastern nations: A multinational prospective research of INICC

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Abstract

Objective: To identify urinary catheter (UC)–associated urinary tract infection (CAUTI) incidence and risk factors.

Design: A prospective cohort study.

Setting: The study was conducted across 623 ICUs of 224 hospitals in 114 cities in 37 African, Asian, Eastern European, Latin American, and Middle Eastern countries.

Participants: The study included 169,036 patients, hospitalized for 1,166,593 patient days.

Methods: Data collection took place from January 1, 2014, to February 12, 2022. We identified CAUTI rates per 1,000 UC days and UC device utilization (DU) ratios stratified by country, by ICU type, by facility ownership type, by World Bank country classification by income level, and by UC type. To estimate CAUTI risk factors, we analyzed 11 variables using multiple logistic regression.

Results: Participant patients acquired 2,010 CAUTIs. The pooled CAUTI rate was 2.83 per 1,000 UC days. The highest CAUTI rate was associated with the use of suprapubic catheters (3.93 CAUTIs per 1,000 UC days); with patients hospitalized in Eastern Europe (14.03) and in Asia (6.28); with patients hospitalized in trauma (7.97), neurologic (6.28), and neurosurgical ICUs (4.95); with patients hospitalized in lower–middle-income countries (3.05); and with patients in public hospitals (5.89).

The following variables were independently associated with CAUTI: Age (adjusted odds ratio [aOR], 1.01; $P < .0001$), female sex (aOR, 1.39; $P < .0001$), length of stay (LOS) before CAUTI-acquisition (aOR, 1.05; $P < .0001$), UC DU ratio (aOR, 1.09; $P < .0001$), public facilities (aOR, 2.24; $P < .0001$), and neurologic ICUs (aOR, 11.49; $P < .0001$).

Conclusions: CAUTI rates are higher in patients with suprapubic catheters, in middle-income countries, in public hospitals, in trauma and neurologic ICUs, and in Eastern European and Asian facilities.

Based on findings regarding risk factors for CAUTI, focus on reducing LOS and UC utilization is warranted, as well as implementing evidence-based CAUTI-prevention recommendations.

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Rates of catheter-associated urinary tract infection (CAUTI) are significantly higher in low- and middle-income countries (LMICs) compared to high-income countries.[1,2] A report from the International Nosocomial Infection Control Consortium (INICC) showed that the CAUTI rate in LMICs was 3.16 CAUTIs per 1,000 UC days.[2] A report from the US Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN) reported 1.3 CAUTIs per 1,000 urinary catheter (UC) days.[3]

Recent studies showed that CAUTI is an independent and significant risk factor for mortality in the ICU.[4–6] Mortality among ICU patients without any healthcare-associated infection (HAI) is 17.1%; mortality is 30.15% among patients with CAUTI and 63.4% among those with for CAUTI plus central-line–associated bloodstream infections plus ventilator-associated pneumonia.[2] CAUTIs are associated with additional costs of $589 per infection.[7]

Studies identified the following variables as risk factors for CAUTI: female sex,[8] age >50 years,[9] increased days of catheterization,[10] increased length of stay in ICU,[11] following a urological surgical procedure,[12] mobility issues,[13] diabetes,[14] hypertension,[15] and spinal cord lesions,[16] among others.

However, no study has concurrently examined different LMICs or different UC types to determine CAUTI risk factors in ICUs. Furthermore, no prospective study has been conducted over 8 years. Additionally, no study has examined simultaneously the relationships between the following 11 variables and their association with CAUTI: (1) age, (2) sex, (3) length of stay (LOS) prior to CAUTI acquisition, (4) UC days prior to CAUTI acquisition, (5) UC device utilization (DU) ratio as a marker of patient illness severity, (6) UC types, (7) hospitalization type, (8) ICU type, (9) facility ownership, (10) World Bank country classification by income level, and (11) period.

In this study, we report CAUTI incidence rates stratified by country, by region, by ICU type, by facility ownership type, by World Bank country classification by income level, and by UC type. We also sought to determine whether the aforementioned 12 variables were CAUTI risk factors.

Materials and methods

Study population and design

This multinational, multicenter, cohort, prospective study was carried out with patients admitted to 623 ICUs of 224 hospitals in 114 cities in 37 countries of Africa, Asia, Eastern Europe, Latin

America, and the Middle East between January 1, 2014, and February 12, 2022.

Prospective cohort surveillance of healthcare-associated infections

Participants in the study were hospitals that were members of INICC. Each patient's data were compiled at the time of ICU admission. Infection prevention professionals (IPPs) visited each patient's bedside daily from the time of admission until discharge. The INICC Surveillance Online System (ISOS) was used to gather data on all prospectively included patients who were admitted to an ICU. IPPs carry a tablet to each hospitalized patient's bedside in the ICU, sign in to the ISOS, and upload patient data in real time.[17]

The data collected at the time of patient admission contain information about the location, such as the setting, country, city, admission date, ICU type, as well as patient data, sex, age, hospitalization type, and invasive device use. Until patient discharge, IPPs upload data on the patient's invasive devices and positive cultures.

The institutional review boards of the participating hospitals approved this study. The names of the hospital and the patients remain confidential.

INICC surveillance online system

INICC CAUTI surveillance is carried out using an online platform, the ISOS, which includes CDC/NHSN criteria and methods.[18] In addition, the ISOS collects patient-specific information on all patients, with and without HAI.[17] To estimate CAUTI risk factors, data from all patients admitted to the ICU allow matching by various characteristics.

Training of infection prevention professionals

This training of IPPs consists of 4 meetings in which the INICC team reviews how to conduct surveillance and how to upload it to the ISOS. In addition, videos with the same content as the webinar are provided to IPPs. IPPs will also view PDF tutorials that have the same information as the webinar. The IPPs are always able to reach the INICC team by phone, text message, WhatsApp, FaceTime, and/or email with their questions. IPPs upload surveillance data during the training and simultaneously share a screen with the INICC team to let the INICC team check the accuracy of each step of the process. The INICC team trains IPPs to generate a report of surveillance using the ISOS. IPPs generate a report during the training and simultaneously share the screen with the INICC team to let the INICC team check the accuracy of each step of the process. The IPPs also create a PDF report and send it to the INICC team by email. The INICC team will make the same report at the INICC office to compare the 2 reports and find any mistakes in how the graphs were made or processed.

Data validation

When IPPs upload the results of the culture to the ISOS, the ISOS promptly displays a notice and directs the IPP to an ISOS online module where they can check all the CDC HAI criteria to verify the presence and type of HAI.[17] Each day, the ISOS checks UC DU. When a bias on patient days or device usage is discovered from admission to discharge, the ISOS notifies the IPPs. If the ISOS detects a lack of use of any kind of device on any given day, it sends a message to the IPPs to remind them to upload any missing devices or upload the discharge of the patient. This approach significantly reduces biases associated with UC days, UC DU ratio, patient days, and discharge conditions.[17]

Study definitions

Healthcare-associated infection

The CDC definitions of CAUTI in 2014 and all subsequent updates through 2022 were utilized during surveillance.[18] The CDC definitions of catheter-associated urinary tract infections are available in the Supplementary Materials (online). The current and updated CDC definitions of HAIs have been used by all IPPs of all participant hospitals over the 8 years of this study. That is, our IPPs started using the newly revised definitions whenever the CDC updated them.[18] The CDC NHSN definitions exclude patients with suprapubic catheters from CAUTI surveillance. Suprapubic catheter–associated UTIs were defined using the CDC NHSN definitions but were applied to patients with suprapubic catheters.

Indwelling urethral urinary catheter

A drainage tube that is inserted into the urinary bladder through the urethra, is left in place, and is connected to a drainage bag (including leg bags). These devices are also often called Foley catheters. Indwelling urethral urinary catheters that are used for intermittent or continuous irrigation are also included in CAUTI surveillance.[18]

Suprapubic catheter

Suprapubic catheterization refers to the placement of a drainage tube into the urinary bladder just above the pubic symphysis.[19]

Urinary catheter device utilization ratio

Urinary catheter device utilization ratio (UC DU) was calculated as a 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 risk factor. The UC DU ratio also served as a marker for the severity of illness of patients, which is an intrinsic risk factor for HAI.[18]

World Bank country classifications by income level

The World Bank categorizes nations into 4 income groups based on their economies: low-, lower–middle-, upper–middle-, and high-income countries. The classifications are based on the gross national income (GNI) per capita in the current USD. The GNI of low-income nations is <$1,045 USD. Lower–middle class are those having a GNI between $1,046 and $4,095. Those with a GNI between $4,096 and $12,695 have an upper–middle income. Those with high income have a GNI >$12,695.[20]

Facility and institution ownership type

Publicly owned facilities are owned or controlled by a public corporation or a governmental body, where control is the capacity to decide on the corporate strategy. Not-for-profit, privately owned facilities are 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. For-profit, privately owned facilities are legal organizations created to produce goods and services with the potential to bring in a profit or other financial gains for their owners.[21]

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Table 1. Setting and Patient Characteristics[a]

Variable	No. (%)
Total patients	169,036
Total patient days	1,166,593
Average LOS, mean (±SD)	6.90 (±9.19)
Sex	
Male	102,479 (60.63)
Female	66,557 (39.37)
Age, mean (±SD)	50.2 (±25.02)
Survival status	
Alive	144,651 (85.57)
Death	24,385 (14.43)
Patients per hospitalization type	
Medical hospitalization	121,559 (71.91)
Surgical hospitalization	47,477 (28.09)
CAUTIs	2,010
Invasive device utilization	
Device days and device utilization ratio	
UC-utilization ratio, mean (±SD)	0.62 (±0.72)
Total UC days	710,205,
UC days, mean (±SD)	4.20 (±6.94)
No. of UC days per type of CL	
Indwelling urethral catheter	707,150 (99.57)
Suprapubic catheter	3,055 (0.43)
Setting and facility characteristics	
ICUs	623
Patients admitted per type of ICU	
Medical-surgical ICU	105,009 (62.12)
Medical ICU	19,614 (11.60)
Pediatric ICU	1,0812 (6.40)
Coronary ICU	10,571 (6.25)
Cardiothoracic ICU	7,964 (4.71)
Surgical ICU	5,250 (3.11)
Adult oncology ICU	3,312 (1.96)
Neurosurgical ICU	2,513 (1.49)
Neurologic ICU	1,522 (0.90)
Pediatric oncology ICU	1,481 (0.88)
Respiratory ICU	517 (0.31)
Trauma ICU	471 (0.28)
Hospitals	224
Patients admitted per facility ownership	
Publicly owned facilities	52,184 (30.87)
For-profit, privately owned facilities	59,780 (35.37)
Teaching hospitals	47,565 (28.14)
Not-for-profit, privately owned facilities	9,507 (5.62)
Cities	114
Countries	38
Countries, stratified per income level according to World Bank	
Lower–middle-income country	8 (26.67)
Upper–middle-income country	17 (56.67)
High-income country	5 (16.67)

Note. ICU, intensive care unit; UC, urinary catheter; LOS, length of stay; CAUTI, catheter-associated urinary tract infections; SD, standard deviation.
[a]Data collected from January 1, 2014, to February 12, 2022.

Statistical analysis

To estimate the incidence of CAUTI per 1,000 UC days, we divided the number of CAUTIs by number of UC days and multiplied the result by 1,000. We identified CAUTI rates per 1,000 UC days and UC DU ratios stratified by country, by ICU type, by facility ownership type, by World Bank country classification by income level, and by UC type.

To estimate risk for CAUTI, patients with and without CAUTI were compared using multiple logistic regression. Statistically significant variables were associated independently with an increased risk for CAUTI. The Wald test was employed as the test statistic, and a 2-tailed type 1 error rate of .05 was chosen as the level of statistical significance. The adjusted odds ratios (aORs) and associated 95% confidence intervals (CIs) for statistically significant factors were calculated from the results of multiple logistic regression.

We analyzed the following 11 independent variables and its association with the outcome (CAUTI): (1) age; (2) sex; (3) LOS before acquiring a CAUTI; (4) UC days before acquisition of CAUTI; (5) UC DU ratio as a marker of severity of illness of patient; (6) type of UC (suprapubic, external, indwelling urethral); (7) hospitalization type (medical or surgical); (8) ICU type (ie, cardiothoracic, neurologic, neurosurgical, adult oncology, medical, medical-surgical, pediatric, respiratory, surgical, trauma, coronary, or pediatric oncology); (9) facility ownership (publicly owned; not-for-profit, privately owned; for-profit, privately owned; or teaching hospitals)[21]; (10) income level per country according to World Bank (lower–middle, upper–middle, or high)[20]; and (11) period (period 1: 2014–2016, period 2: 2017–2019, period 3: 2020–2022). The evaluated outcome was the acquisition of CAUTI according to the CDC NHSN definitions.[18]

For analysis of CAUTI risk factors we use data of 37 countries: Argentina, Bahrain, Brazil, Bulgaria, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, India, Jordan, Kosovo, Kuwait, Lebanon, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, Slovakia, Sri Lanka, Thailand, Turkey, United Arab Emirates, Venezuela, and Vietnam. All statistical analyses were performed using R software version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

From January 1, 2014, to February 12, 2022, more than 8 years, a multinational, multicenter, cohort, prospective surveillance study of CAUTIs was conducted across 623 ICUs of 224 hospitals in 114

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Table 2. CAUTI Rates Stratified by Country, by Region, by ICU Type, by Facility Ownership Type, by World Bank Country Classifications by Income Level, and by Urinary Catheter Type

Country[a]	World Bank Country Classification by Income	Patients, No.	Patient Days, No.	UC Days, No.	CAUTI, No.	CAUTI Rate[b]	95% CI
1. Argentina	Upper Middle	6,008	50,526	37,689	110	2.92	2.90–2.94
2. Bahrain	High	1,224	11,205	8,617	21	2.44	2.40–2.47
3. Brazil	Upper Middle	10,513	88,742	39,123	141	3.60	3.59–3.62
4. Bulgaria	Upper Middle	469	7,090	6,934	15	2.16	2.13–2.20
5. Colombia	Upper Middle	7,740	56,015	27,505	53	1.93	1.39–1.42
6. Costa Rica	Upper Middle	596	2,715	2,174	0	0.00	0
7. Dominican Republic	Upper Middle	1,418	10,569	5,208	28	5.38	5.31–5.44
8. Ecuador	Upper Middle	944	16,826	6,695	65	9.71	9.63–9.78
9. Egypt	Lower Middle	5,477	63,789	24,207	76	3.14	3.12–3.16
10. India	Lower Middle	77,176	760,071	295,593	1,072	3.63	3.62–3.63
11. Jordan	Lower Middle	5,104	28,696	22,865	54	2.36	2.34–2.38
12. Kosovo	Lower Middle	125	2,365	631	3	4.75	4.59–4.93
13. Kuwait	High	7,044	9,7150	47,992	57	1.19	1.18–1.20
14. Lebanon	Upper Middle	4,768	43,124	25,762	49	1.90	1.88–1.92
15. Macedonia	Upper Middle	29	229	239	2	8.37	8.00–8.74
16. Malaysia	Upper Middle	4,960	40,171	29,345	96	3.27	3.25–3.29
17. Mexico	Upper Middle	6,893	54,906	42,841	218	5.09	5.07–5.11
18. Mongolia	Lower Middle	2,458	23,363	10,427	54	5.18	5.14–5.22
19. Morocco	Lower Middle	34	784	116	2	17.24	16.49–18.01
20. Nepal	Lower Middle	2,009	25,806	9,095	18	1.98	1.95–2.01
21. Pakistan	Lower Middle	578	4,842	3,168	122	38.51	38.29–38.73
22. Panama	Upper Middle	342	3,091	2,530	14	5.53	5.44–5.63
23. Papua New Guinea	Lower Middle	17	106	11	1	90.91	85.36–96.72
24. Peru	Upper Middle	114	908	234	4	17.09	16.57–17.63
25. Philippines	Lower Middle	1,166	8,021	4,959	24	4.84	4.78–4.90
26. Poland	High	1,404	16,625	14,206	82	5.77	5.73–5.81
27. Romania	Upper Middle	977	8,465	7,167	328	45.77	45.61–45.92
28. Russia	Upper Middle	98	1,116	361	1	2.77	2.60–2.95
29. Saudi Arabia	High	27,276	322,683	231,318	650	2.81	2.80–2.82
30. Serbia	Upper Middle	54	623	18	6	333.33	324.95–341.88
31. Slovakia	High	861	8,614	7,437	82	11.03	10.95–11.02
32. Sri Lanka	Lower Middle	327	2,398	1,883	4	2.12	2.06–2.19
33. Thailand	Upper Middle	649	2,774	1,565	1	0.64	0.60–0.68
34. Turkey	Upper Middle	5,120	12,2193	63,266	263	4.16	4.14–4.17
35. United Arab Emirates	High	383	3,209	300	1	3.33	3.13–3.55
36. Venezuela	Lower Middle	1,110	5,409	4,097	16	3.91	3.85–3.97
37. Vietnam	Lower Middle	4,089	49,906	22,262	93	4.18	4.15–4.20
Region[c]							
Eastern Europe		4,009	45,127	36,993	519	14.03	13.99–14.07
Asia		93,403	917,352	378,297	1,484	3.92	3.91–3.93
Middle East		60,239	711,140	469,906	1,555	3.31	3.30–3.31
Latin America		42,711	386,857	216,088	706	3.27	3.26–3.28

(*Continued*)

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Table 2. (*Continued*)

Country[a]	World Bank Country Classification by Income	Patients, No.	Patient Days, No.	UC Days, No.	CAUTI, No.	CAUTI Rate[b]	95% CI
ICU type[d]							
Trauma		471	2,319	1,004	8	7.97	7.79–8.14
Neurologic		1,522	10,538	6,524	41	6.28	6.22–6.35
Neurosurgical		2,513	22,244	14,536	72	4.95	4.92–4.99
Medical		19,614	141,124	8,1472	292	3.58	3.57–3.60
Coronary		10,571	65,390	24,840	87	3.50	3.07–3.11
Surgical		5,250	30,947	21,588	70	3.24	3.22–3.27
Adult oncology		3,312	15,980	14,080	41	2.91	2.88–2.94
Respiratory		517	6,087	3,634	10	2.75	2.70–2.81
Pediatric		10,812	84,205	28,182	73	2.59	2.57–2.61
Medical-surgical		105,009	732,719	505,173	1285	2.54	2.53–2.55
Cardiothoracic		7,964	46,265	27,321	30	1.09	1.08–1.11
Pediatric oncology		1,481	8,775	4,304	1	0.23	0.22–0.25
Pooled		169,036	1,166,593	732,658	2010	2.74	2.74–2.75
Lower–middle income							
Pooled		84,911	513,215	292,972	893	3.05	3.04–3.05
Publicly owned facilities		9,666	58,831	34,300	202	5.89	5.86–5.92
For-profit, privately owned facilities		37,046	213,442	133,382	441	3.31	3.29–3.32
Teaching hospitals		28,875	190,686	101,767	193	1.89	1.88–1.91
Not-for-profit, privately owned facilities		9,324	50,256	23,523	57	2.42	2.40–2.44
Upper–middle income							
Pooled		50,470	351,025	228,264	733	3.21	3.20–3.22
Publicly owned facilities		12,205	88,166	52,152	157	3.01	2.99–3.02
For-profit, privately owned facilities		20,227	122,886	74,232	161	2.17	2.16–2.18
Teaching hospitals		17,855	139,297	101,479	411	4.05	4.03–4.06
Not-for-profit, privately owned facilities		183	676	401	4	9.98	9.67–10.29
High income							
Pooled		33,655	302,353	211,422	384	1.82	1.81–1.83
Publicly owned facilities		30,313	272,711	190,017	341	1.79	1.78–1.80
For-profit, privately owned facilities		2,507	22,027	14,303	10	0.70	0.69–0.71
Teaching hospitals		835	7,615	7,102	33	4.65	4.60–4.70
UC type							
Indwelling urethral		113,790	862,028	707,150	1,794	2.54	2.53–2.54
Suprapubic		431	4,099	3,055	12	3.93	3.86–4.00

Note. ICU, intensive care unit; CI, confidence interval; UC, urinary catheter; CAUTI, catheter-associated urinary tract infection; CI, confidence interval.
[a]Countries are listed alphabetically.
[b]Rate of catheter associated urinary tract infection per 1,000 urinary catheter days.
[c]Regions are listed in order of the highest to lowest CAUTI rate.
[d]ICUs are listed in order of the highest to lowest CAUTI rate.

cities in 37 countries from Africa, Asia, Eastern Europe, Latin America, and the Middle East, currently participating in INICC.

In this cohort study, the length of participation of hospitals was variable, ranging from 1.1 to 226.07 months (mean, 38.47; standard deviation [SD], 42.62). Table 1 shows data on setting and patient characteristics. Table 2 shows CAUTI rate per 1,000 UC days stratified by country, by region, by ICU type, by facility ownership type, by World Bank country classifications by income level, and by urinary catheter type. Low-income countries were not included in this study; only middle-income countries and high-income countries were included. Figure 1 shows the CAUTI rate per 1,000 UC days stratified per country.

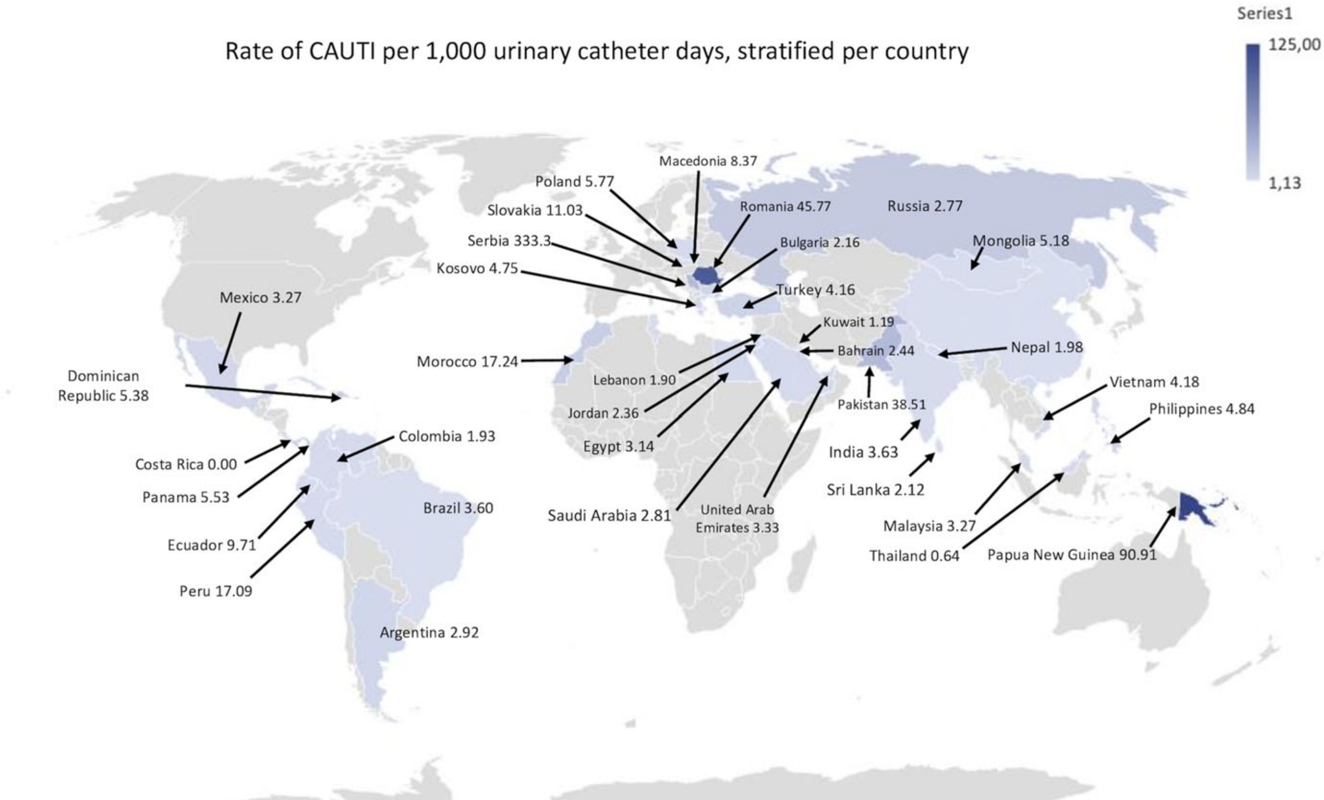

Figure 1. Rates of CAUTI per 1,000 urinary catheter-days stratified per country.

The pooled CAUTI rate per 1,000 UC days was 2.83. The highest CAUTI rates occurred in patients with suprapubic catheters; in patients hospitalized in Eastern European facilities; in Asian facilities hospitalized at trauma, neurologic, and neurosurgical ICUs; in patients hospitalized at facilities of middle-income countries; and in patients hospitalized at publicly owned facilities. Countries with the lowest CAUTI rates were Costa Rica, Thailand, Kuwait, Lebanon, and Colombia. The countries with the highest CAUTI rates were Morocco, Pakistan, Romania, Papua New Guinea, and Serbia (Table 2).

Using multiple logistic regression, the following variables were identified as significantly associated with CAUTI (Table 3): age, with risk increasing 1% yearly; female sex; LOS prior to acquisition of CAUTI, with risk increasing 4% daily; number of UC days prior to acquisition of CAUTI, with risk increasing 1% per UC day; UC DU ratio; hospitalized at a publicly owned facility; location in an upper–middle-income country, and period. The ICU type with highest risk was neurologic, followed by neurosurgical, adult oncology, medical, trauma, surgical, medical-surgical, pediatric, respiratory, and coronary ICU. After adjusting by all confounders, type of UC, surgical hospitalization, teaching hospital, and for-profit, privately owned facility were not associated with CAUTI risk.

Discussion

We identified CAUTI rates stratified by ICU type, by country, by region, by income level according to the World Bank, by facility ownership, and by type of urinary catheter. The following variables were independently and significantly associated with risk for CAUTI: age, female sex, public owned facility, middle-income country, neurologic ICU, and period.

The pooled rates of CAUTI in our study are similar to those pooled CAUTI rates reported by the INICC.[2] The CAUTI rate in LMICs is 3.16 CAUTIs per 1,000 UC days according to the last INICC report.[2] However, pooled rates of CAUTI in our study are higher than those of the CDC NHSN, which reports 1.3 CAUTI per 1,000 UC days.[3]

In our study, we identified age as a risk factor for CAUTI. Similarly, in a study by Liu et al[22] at a neurosurgical ICU, age >60 years was identified as a risk factor for CAUTI. We identified sex as a risk factor for CAUTI. Likewise, in a study by Perrin et al[15] at a neurologic ICU, female sex was identified as a risk factor for CAUTI. The incremental risk of CAUTI increased by 5% per day if the UC remains in place. Consistently, a study conducted by Al-Hazmi[23] showed the role of LOS prior to CAUTI acquisition as a significant risk factor for CAUTI. The UC DU was identified as a risk factor for CAUTI. Similarly, as stated by Burton et al,[24] the dominant risk factor for acquiring a CAUTI was the duration of UC days.

We identified that the CAUTI rate using suprapubic catheters was higher than that for patients with indwelling urethral catheters. However, when we applied multiple logistic regression to identify a type of UC as an independent risk factor for CAUTI, both types of UC have similar risk, as shown by the overlap of the 95% CIs. Conversely, according to Gibson et al,[25] suprapubic catheters had a lower CAUTI incidence rate compared to indwelling urethral catheters.

In this study, the highest CAUTI rate was seen in patients hospitalized in trauma, neurologic, and neurosurgical ICUs. When

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Table 3. Multiple Logistic Regression Analysis of Risk Factors for CAUTI

Variable	aOR	95% CI	*P* Value
Age	1.01	1.01–1.02	<.0001
Sex, female	1.39	1.26-1.51	<.0001
Length of stay	1.05	1.05–1.06	<.0001
UC days	0.98	0.97–0.98	<.0001
UC DU ratio	1.09	1.07–1.12	<.0001
Surgical hospitalization	0.99	0.89–1.12	.99
Reference: Lack of use of UC			
Indwelling urethral catheter	4.34	3.69–5.09	<.0001
Suprapubic catheter	6.42	3.45–11.95	<.0001
Reference: Not-for-profit, privately owned facilities			
Publicly owned facilities	2.24	1.66–3.01	<.0001
For-profit, privately owned facilities	1.27	0.95–1.69	.11
Teaching hospitals	1.67	1.25–2.23	<.0001
Reference: High-income country			
Lower–middle-income country	1.71	1.44–2.01	<.0001
Upper–middle-income country	1.94	1.66–2.26	<.0001
Reference: Cardiothoracic ICU			
Neurologic ICU	11.49	6.92–19.11	<.0001
Trauma ICU	7.99	3.58–17.84	<.0001
Neurosurgical ICU	6.78	4.31–10.65	<.0001
Medical ICU	4.95	3.31–7.39	<.0001
Adult oncology ICU	4.94	2.96–8.25	<.0001
Surgical ICU	4.08	2.61–6.37	<.0001
Medical-surgical ICU	3.82	2.61–5.61	<.0001
Pediatric ICU	3.55	2.22–5.66	<.0001
Coronary ICU	3.38	2.17–5.26	<.0001
Respiratory ICU	3.11	1.46–6.61	<.0001
Pediatric oncology ICU	0.46	0.06–3.42	.44
Reference: Period 3 (2020–2022)			
Period 1 (2014–2016)	2.21	1.79–2.71	<.0001
Period 2 (2017–2019)	2.09	1.69–2.56	<.0001

Note. ICU, intensive care unit; UC, urinary catheter; DU, device utilization; LOS, length of stay; CAUTI, catheter-associated urinary tract infection; aOR, adjusted odds ratio; CI, confidence interval.

applying multiple logistic regression, the study noted that admission into the neurologic, trauma, and neurosurgical ICUs had the highest risk for CAUTI. The UC DU ratio was the highest for the corresponding ICUs according to data collected by hospitals participating in the National Healthcare Safety Network (NHSN) and reported to the US Centers for Disease Control and Prevention (CDC), and a higher UC DU ratio is associated with a higher risk of CAUTI.[3]

For patients hospitalized at publicly owned facilities, the CAUTI rate was the highest; for those at for-profit, privately owned facilities, it was intermediate; and for those at teaching hospitals, it was the lowest. Applying multiple logistic regression, patients admitted to publicly owned facilities had a significantly higher risk factor for CAUTI than patients admitted to other types of facilities. This finding was not consistent with a previous study that found that teaching hospitals had a CAUTI rate similar to publicly owned facilities and for-profit, privately owned facilities.[26]

Furthermore, for patients hospitalized in Eastern European facilities, the CAUTI rate was the highest; for those in Asian facilities, it was intermediate; and patients in Middle Eastern and Latin American facilities had the lowest CAUTI rate. We identified and showed those countries with higher CAUTI rates and those with the lowest CAUTI rate, and this was associated with the income of the country. Meanwhile, if the income was lower, the CAUTI rate was higher.[20] The current study found that the CAUTI rate in lower–middle-income countries and upper–middle-income countries was similar, but both were higher than for those hospitalized in high-income countries. When applying multiple logistic regression, the risk of CAUTI was higher in upper-middle-income countries compared with high-income countries. This finding is consistent with a previous study in which lower–middle income countries had higher CAUTI rates than upper–middle income countries, showing that lower income is associated with a higher CAUTI rate, but in this particular study, high-income countries were not included.[26] Analyzing the period, we discovered that the risk for CAUTI decreased over time, which is consistent with more recent improvements in infection prevention techniques than previously.

Some of the CAUTI risk factors identified in our study are unlikely to change, such as age, sex, the income level of the country, facility ownership, and ICU type. However, some of the risk factors for CAUTI we identified can be modified, for example, LOS prior to acquisition of a CAUTI, and UC utilization. Based on our findings, we should focus on strategies to reduce UC utilization, to reduce LOS, and to implement an evidence-based set of CAUTI prevention recommendations, such as those published by HICPAC.[27] Also, the very high rate of CAUTI prevalent in LMICs[1,2] can be reduced by utilizing a strategy of monitoring compliance with recommendations and providing performance feedback to healthcare personnel, as demonstrated in several LMICs.[28–33]

Our study had several limitations. First, this study is not representative of all hospitals in LMICs because it is a component of a surveillance system in which hospitals voluntarily participate for free. Second, because the hospitals that participate in our surveillance system are likely the ones that have a higher-quality CAUTI surveillance and prevention program, the CAUTI rates in our study were presumably lower than the CAUTI rates in other hospitals that did not participate in our study. Third, we did not stratify hospital by impact of bed size, services offered, and specialty services. Instead, we stratified them by type of ICU, facility ownership, income level according to the World Bank, by country, and by region, which are more relevant for LMICs, as previously demonstrated.[26,34] Lastly, severity illness scores were not collected by the IPPs of the participating institutions; instead, we used the UC DU ratio as a marker for severity of patient illness.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.215

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