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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

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Summary
Objectives: To assess the impact of a multidimensional infection control approach on the reduction of catheter-associated urinary tract infection (CAUTI) rates in adult intensive care units (AICUs) in two hospitals in the Philippines that are members of the International Nosocomial Infection Control Consortium.
Materials and methods: This was a before—after prospective active surveillance study to determine the rates of CAUTI in 3183 patients hospitalized in 4 ICUS over 14,426 bed-days. The study was divided into baseline and intervention periods. During baseline, surveillance was performed using the definitions of the US Centers for Disease Control and Prevention and the National Healthcare Safety Network (CDC/NHSN). During intervention, we implemented a multidimensional approach that included: (1) a bundle of infection control interventions,

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(2) education, (3) surveillance of CAUTI rates, (4) feedback on CAUTI rates, (5) process surveillance and (6) performance feedback. We used random effects Poisson regression to account for the clustering of CAUTI rates across time.
Results: We recorded 8720 urinary catheter (UC)-days: 819 at baseline and 7901 during intervention. The rate of CAUTI was 11.0 per 1000 UC-days at baseline and was decreased by 76% to 2.66 per 1000 UC-days during intervention [rate ratio [RR], 0.24; 95% confidence interval [CI], 0.11—0.53; *P*-value, 0.0001].
Conclusions: Our multidimensional approach was associated with a significant reduction in the CAUTI rates in the ICU setting of a limited-resource country.

Introduction

Catheter-associated urinary tract infections (CAUTIs) are among the most common device-associated healthcare-acquired infections (DA-HAIs) in intensive care units (ICUs) [1—3]. CAUTIs are responsible for prolonged hospital lengths of stay, bacterial resistance, morbidity, and increased healthcare costs [4,5]. Recently published studies have shown divergence in terms of the association of CAUTIs with excess mortality, which is related to confounding by unmeasured variables [4,6—8].

The incidence of CAUTI is frequently underestimated in most hospitals in limited-resource countries, as in many cases; basic infection control and surveillance programs cannot be systematically implemented [9]. In low-income countries, the rates of CAUTI are 3—5 times higher than in industrialized countries, as reported by the International Nosocomial Infection Control Consortium (INICC) in pooled studies [10], and specifically for the Philippines [11].

The socio-economic level of a country was reported to have an impact on DA-HAI rates in the ICU settings of developing countries; DA-HAI rates were shown to be higher in low-income countries than in lower-middle- and upper-middle-income countries [12,13]. With regard to a country's socio-economic level, in a study conducted in pediatric ICUs, it was determined that lower-middle-income countries had higher CAUTI rates than low-income countries or upper-middle-income countries (5.9 vs. 0.6 CAUTIs per 1000 urinary catheter [UC]-days) [13]. Unfortunately, other studies from developing countries that analyze this issue in adult ICUs (AICUs) are not available.

The scientific literature from developed countries has demonstrated the effectiveness of infection control programs and practice bundles for CAUTI prevention, including hand hygiene [14]; training on care, maintenance, and alternatives to indwelling catheters [15]; education and training on procedures for catheter insertion, management, and removal; inserting urinary catheters only when needed; removing them when not necessary [16]; and maintaining unobstructed urine flow, among other interventions. These control measure are practiced simultaneously with outcome surveillance of CAUTI rates and their consequences, process surveillance, feedback on CAUTI rates, and performance feedback [17]. However, very little was found in the literature on the implementation of prevention strategies and programs in the developing world [18].

The INICC was set up to support hospitals in limited-resource countries in their surveillance and implementation of programs to reduce healthcare-associated infection rates. Hospitals from limited-resource countries contact the INICC to obtain forms and manuals with the necessary guidance. In addition, the INICC also provides administrative and scientific support to upload, process, analyze, and create charts and tables with the collected data.

With the aim of reducing high CAUTI rates in the AICU setting in the Philippines [11], we implemented a multidimensional infection control program from December 2005—2010 — which included six specific interventions for CAUTI prevention: (1) a bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of CAUTI rates, and (6) performance feedback of infection control practices — in 4 AICUs of 2 hospitals from 2 cities in the Philippines. The implementation of the INICC multidimensional program for CAUTI prevention is based on the recommendations and guidelines published by the Society for Health Care Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA) in 2008 [19].

Two reasons justify this study: the reduction of CAUTI in a developing country and the analysis of the particular effect of this novel multidimensional approach with 6 simultaneous interventions on CAUTI prevention in a limited-resource setting.

Patients and methods

Setting and study design

This active, prospective before–after surveillance study was conducted in 4 AICUs in 2 hospitals that are members of the INICC in 2 cities in the Philippines from December 2005—2010. The participating ICUs had infection control teams (ICTs) composed of infection control professionals (ICPs) and a medical doctor with formal education and a background in internal medicine, critical care, infectious diseases, and/or hospital epidemiology. The INICC headquarters' team in Buenos Aires provided the ICTs with centralized education, data analyses, and coordination functions. The Institutional Review Board at each hospital approved the study protocol.

The study was divided into baseline and intervention periods.

Baseline period

The baseline period included only the outcome surveillance and process surveillance.

The length of the baseline period was 3 months for the following reasons:

1. This is the time frame needed to conduct the following activities at INICC headquarters (HQs) in Argentina on a monthly basis: receiving the case report forms (CRFs) completed at all participating ICUs from the Philippines; conducting a validation process for the completed CRFs; sending queries to participating ICUs; receiving and analyzing the replies to queries; uploading the CRF data to proprietary INICC software in Argentina; analyzing the uploaded data; producing monthly reports containing charts and tables with the results of outcome and process surveillance; sending monthly reports to each ICU; and presenting the monthly report of outcome and process surveillance data to health care workers (HCWs) working at the participating ICUs in monthly infection control meetings, with the aims of providing feedback on CAUTI rates and consequences and performance feedback and increasing awareness of CAUTIs to improve compliance with infection control practices.
2. The sample size and the number of months of data collection during the baseline period are sufficient to compare with the sample size and number of months of data collection during the intervention period. From a statistical perspective, the issue is addressed by considering the change in rates over time. The relatively short baseline period may impact the standard error of our estimates. However, we found that this approach will not cause a bias in the results because there are no systematic differences between the two groups.
3. Our priority was to start intervention as early as possible to achieve the desired results: chiefly, the reduction of CAUTI rates and their related consequences.

Intervention period

The intervention period was initiated after 3 months of participation in the INICC program. Because this was a cohort study, each ICU enrolled in the program at different times. Therefore, the analysis on the impact of the INICC intervention includes ICUs with different lengths of intervention periods. The average length of the intervention period was 27.9 months ± 18.2 (SD; range 10—61).

INICC multidimensional infection control approach

The INICC multidimensional infection control approach included the following items: (1) a bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback on CAUTI rates, and (6) performance feedback on infection control practices.

Components of bundle for the prevention of CAUTIs

The bundle consisted of the following interventions [19]:

1. To perform hand hygiene (HH) before insertion and manipulation of a UC.
2. To maintain unobstructed urine flow; i.e., UC on thigh without strangulating.
3. To keep the collecting bag below the level of the bladder at all times; i.e., UC with collecting bag hanging and not allowing urine reflux.
4. To empty the collecting bag regularly and to avoid allowing the draining spigot to touch the collecting container.

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5. To monitor CAUTIs using standardized criteria to identify patients with CAUTIs and to collect UC-days as denominators.

Because of budget limitations, some other effective interventions were discussed but not fully applied or their performance was not surveyed [19]:

1. Appropriate management of indwelling catheters: to properly secure indwelling catheters to prevent movement; to maintain a sterile, continuously closed drainage system; to avoid disconnecting the catheter and drainage tube; and to replace the collecting system by aseptic techniques and after disinfecting the catheter-tubing junction when breaks in aseptic technique, disconnection, or leakage occur.
2. Insertion of UCs only when needed and removal when unnecessary.
3. Use of indwelling urethral catheters for the perioperative period and for selected surgical procedures; urine output monitoring in critically ill patients; management of acute urinary retention and urinary obstruction; and assistance in pressure ulcer healing for incontinent residents.
4. Consideration of other methods for management, including condom catheters or in-and-out catheterization, when appropriate.
5. Use of as small a catheter as possible.
6. Use of gloves, a drape, and sponges; a sterile or antiseptic solution for cleaning the urethral meatus; and a single-use packet of sterile lubricant jelly for insertion.
7. Use of aseptic technique and sterile equipment for insertion.
8. Cleaning of the meatal area as part of routine hygiene.

Education

On a monthly basis, education and training sessions were provided to HCWs on insertion, care, maintenance, alternatives to indwelling catheters, procedures for catheter insertion, management, insertion, and removal. Training for CAUTI prevention was based on the SHEA and IDSA guidelines [19].

INICC surveillance methods

The INICC Surveillance Program included two components: outcome surveillance (DA-HAI rates and their adverse effects, including mortality rates) and process surveillance (adherence to hand hygiene and other basic preventive infection control practices) [20].

Investigators were required to complete outcome and process surveillance forms at their hospitals, which were then sent monthly for analysis to the INICC headquarters office in Buenos Aires.

Outcome surveillance

For outcome surveillance, the ICTs applied the definitions for healthcare-associated infections (HAIs) developed by the US Centers for Disease Control and Prevention (CDC) for the National Healthcare Safety Network (NHSN) program [21]. Outcome Surveillance included CAUTI rates per 1000 UC-days, use of invasive devices (central line, mechanical ventilator, and UC), severity illness score, underlying diseases, use of antibiotics, cultures taken, microorganism profile, bacterial resistance, length of stay, and mortality in the participating ICUs [20].

Additionally, INICC methods were adapted to the limited-resource setting of developing countries due to their different socioeconomic status [20]. The ASIS score was used instead of the APACHE II score due to budget limitations of participating ICUs from this limited-resource country. Thus, we decided to use the ASIS score, as historically used by the CDC National Nosocomial Infections Surveillance (NNIS) [22].

Definition of CAUTI

For the purposes of this study, CAUTI was diagnosed if the patient met one of two criteria. The first criterion was satisfied when a patient with a urinary catheter had one or more of the following symptoms with no other recognized cause: fever (temperature $\geq 38\,^{\circ}$C), urgency, or suprapubic tenderness. The urine culture was positive for 10^5 colony-forming units (CFU) per mL or more, with no more than two microorganisms isolated. The second criterion was satisfied when a patient with a urinary catheter had at least two of the following criteria with no other recognized cause: positive dipstick analysis for leukocyte esterase or nitrate and pyuria (≥ 10 leukocytes/mL) [21].

Process surveillance

Process surveillance was designed to assess compliance with easily measurable key infection control practices, such as surveillance of compliance rates for hand hygiene practices and specific measures for CAUTI prevention. Although HCWs knew that HH practices were to be regularly monitored, they were not aware of the precise schedule and moment in which the observations were occurring [20].

Hand hygiene compliance

HH compliance by HCWs was determined by measuring the frequency of HH compliance when clearly indicated by guidelines. HH practices were monitored by the ICP during randomly selected 1-h direct observation periods, 3 times a week. The ICPs recorded HH opportunities and compliance on a form specifically designed for the study, which listed the ''Five Moments for Hand Hygiene'' as recommended by the World Health Organization [23].

Data on compliance with UC care bundle interventions

UC care compliance was monitored once a day, 5 days a week. The observer supervised and recorded how the infection control interventions included in the bundle were performed by HCWs; that is, UC on thigh without strangulating, UC with collecting bag hanging, and not allowing urine reflux. For this purpose, the forms for UC care monitoring included information such as date, number of inserted catheters, number of catheters over thigh, and number of bags hanging. The observer checked whether the urine collecting bag was hanging on the side of the patient, on the contaminated floor, or elsewhere, if the bag position allowed reflux, and if the catheter was placed on or under the patient's thigh.

Feedback on DA-HAI rates and performance

Every month, the INICC research team at INICC headquarters in Buenos Aires prepared and sent to each ICT a final report on the results of the outcome and process surveillance data sent by investigators at each hospital, i.e., monthly DA-HAI rates, length of stay, bacterial profile and resistance, mortality, compliance with HH and with care of the UC [20].

Feedback on DA-HAI rates and performance feedback were provided to the HCWs working in the AICU by communicating patient outcomes and the assessment of the practices they routinely performed. The resulting rates were reviewed by the ICT at monthly meetings, where charts were analyzed. Statistical graphs and visuals were displayed in prominent locations inside the ICU to provide an overview of rates of DA-HAIs and rates measuring compliance with infection control practices. This infection control tool is important for increasing HCW awareness of patient outcomes at ICUs, enabling the ICT and ICU staff to focus on the necessary issues and to apply specific strategies for the improvement of low compliance rates and the reduction of high DA-HAI rates.

Statistical methods

Patients' characteristics at baseline and during the last 3 months of the intervention period in each AICU were compared using Fisher's exact test for dichotomous variables and unmatched Student's *t*-test for continuous variables. The 95% confidence intervals (CIs) were calculated using VCStat (Castiglia, Buenos Aires, Argentina). Relative risk (RR) ratios with 95% CIs were calculated for comparisons of CAUTI rates using EPI Info V6. *P*-values < 0.05 by two-sided tests were considered to be significant.

We performed two types of analysis to evaluate the impact of our interventions. First, we performed an analysis to compare the data from the first 3 months (baseline period) with the remaining pooled months (intervention period) using RR, 95% CIs, and *P*-values.

Second, we used Poisson regression to analyze the progressive CAUTI rate reduction. For this purpose, the data were divided into baseline for the first 3 months and follow-up periods divided into a 6-month period for the first year and yearly over the next months. We compared the CAUTI rates in each period with the CAUTI rate at baseline, using as the baseline for each follow-up period only the hospitals that contributed to follow-up in that period (i.e., excluding from the baseline comparisons hospitals with long lengths of follow-up that contributed shorter lengths of surveillance). We used random effects Poisson regression to account for within-hospital clustering of CAUTI rates across time. These models were estimated using Stata 11.0. For this analysis, we used incidence rate-ratio (IRR), 95% CIs, and *P*-values.

Results

During the study period, 3183 patients were hospitalized in 4 AICUs over 14,426 days, amounting to 8720 UC-days. Participating hospitals were classified according to type of hospital, type of ICU, number of ICUs, and number of patients in each ICU. The first ICUs to participate in the study were enrolled in December 2005, and the most recent data included in our analysis dated from December 2010 (Table 1).

Patient characteristics, such as UC duration mean, surgical stay, pulmonary disease, abdominal surgery, cancer, endocrine metabolic diseases, renal impairment, and immune-compromised

Table 1 Characteristics of the participating hospitals (from December 2005—2010).

Data	AICUs, *n*	AICU patients, *n*
Type of AICU, *n* (%)		
Surgical	1 (25%)	225
Medical cardiac	1 (25%)	1408
Medical	1 (25%)	165
Medical surgical	1 (25%)	1383
All AICUs	4 (100%)	3183
Type of hospital, *n* (%)		
Private community	1 (50%)	2958
Academic teaching	1 (50%)	225
All hospitals	2 (100%)	3183

AICU, adult intensive care unit.

condition, were similar during both periods. However, the mean age of patients, proportion of women, and presence of previous infections were higher during the intervention period (Table 2).

During the baseline period, we recorded 819 UC-days, for a UC use mean of 0.67. There were 9 CAUTIs, for an overall baseline rate of 11.0 CAUTIs per 1000 UC-days (Table 2).

During the implementation of our multidimensional approach, HH compliance improved significantly, from 57.23% to 78.21%. Similarly, compliance rates with other measures also increased: the correct positioning of the urinary catheter (over the thigh) improved from 41.56%

Table 2 Characteristics of patients, hand hygiene compliance, and urinary catheter care during the baseline and intervention periods.

Patient characteristics	Baseline	Intervention	RR[a]	95% CI	*P*-value
Number of patients	283	2898	—	—	—
Study period by hospital in months, mean ± SD (range)	3	27.9 ± 18.2 (10—61)	—	—	—
UC duration, mean ± SD	2.9 ± 4.1	2.73 ± 4.2	—	—	0.52
Age, mean ± SD	59 ± 17.28	62.21 ± 17.13	—	—	0.003
ASIS score, mean ± SD	2.81 ± 1.4	2.62 ± 1.15	—	—	0.034
Male, *n* (%)	199 (70%)	1738 (60%)	0.85	0.74—0.99	0.0332
Female, *n* (%)	84 (30%)	1158 (40%)	—	—	—
Surgical stay, *n* (%)	27 (10%)	339 (12%)	1.28	0.86—1.9	0.217
Pulmonary disease, *n* (%)	7 (2%)	142 (5%)	1.98	0.93—4.24	0.0714
Abdominal surgery, *n* (%)	4 (1%)	29 (1%)	0.71	0.25—2.02	0.5161
Cancer, *n* (%)	8 (3%)	155 (5%)	1.9	0.93—3.84	0.075
Previous infections, *n* (%)	7 (3%)	333 (14%)	5.36	2.54—11.33	0.0001
Endocrine diseases, *n* (%)	13 (5%)	143 (5%)	1.08	0.61—1.9	0.8
Renal impairment, *n* (%)	24 (8%)	173 (6%)	0.7	0.46—1.08	0.106
Immune compromise, *n* (%)	4 (1%)	23 (1%)	0.56	0.2—1.62	0.28
Hand hygiene compliance % (*n*/*n*)	57.23% (297/519)	78.21% (2872/3672)	1.37	1.21—1.54	0.0001
Urinary catheter on thigh % (*n*/*n*)	41.56% (389/936)	88.84% (7485/8425)	2.14	1.93—2.37	0.0001
Urine bag hanging % (*n*/*n*)	41.56% (389/936)	92.28% (7775/8425)	2.22	2.01—2.46	0.0001

RR, rate ratio; CI, confidence interval; SD, standard deviation; CAUTI, catheter-associated urinary tract infection; UC, urinary catheter; ASIS, average severity of illness score.

[a] For HH, relative risk rather than rate ratios is calculated.

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Table 3 Catheter-associated urinary tract infection rates, mortality rates, and device use in the baseline and intervention periods.

Patients' outcomes	Baseline	Intervention	RR	95% CI	*P*-value
Patients, *n*	283	2898			
Bed-days, *n*	1222	13,204			
UC-days, *n*	819	7901			
UC use, mean	0.67	0.6	0.9	0.83–0.96	0.002
CAUTI, *n*	9	21			
CAUTI rate per 1000 UC-days	11	2.66	0.24	0.11–0.53	0.0001

RR, rate ratio; CI, confidence interval; SD, standard deviation; CAUTI, catheter-associated urinary tract infection; UC, urinary catheter.

to 88.84%, and urine bag hanging improved from 41.56% to 92.88% (Table 2).

Merging all data from the intervention period, after the implementation of the multidimensional approach, we recorded 7901 UC-days, for a UC use mean of 0.60. There were 21 CAUTIs for an incidence density of 2.66 per 1000 UC-days. These results revealed a CAUTI rate reduction of 76% from baseline (11.0–2.66 CAUTIs per 1000 UC-days; RR 0.24, 95% CI 0.22–0.53, *P* 0.0001) (Table 3). To compare the progressive reduction in the rates of CAUTI for the entire study, we used Poisson regression. We divided the months of participation into 9–12 month periods during the first year, and into yearly periods in the second and third years. We noted a progressive reduction in the incidence of CAUTI (Table 4).

The microorganism profile is shown in Table 5. The predominant uropathogen isolated in both periods was *Candida* spp. (33%), with an increase in its frequency by 10% from baseline to the intervention period. The next most common uropathogens identified during the baseline period included *Stenotrophomonas* spp., coagulase-negative Staphylococci, *Corynobacter*, and *Klebsiella* spp.

Table 5 Microorganism related to catheter-associated urinary tract infection in intensive care units in the baseline and intervention periods.

Isolated microorganisms	Baseline	Intervention
Candida spp. % (*n*)	33% (2)	43% (3)
Stenotrophomonas spp. % (*n*)	17% (1)	14% (1)
Coagulase-negative Staphylococci % (*n*)	17% (1)	0% (0)
Corynobacter % (*n*)	17% (1)	0% (0)
Klebsiella spp. % (*n*)	17% (1)	0% (0)
Acinetobacter % (*n*)	0% (0)	14% (1)
Citrobacter spp. % (*n*)	0% (0)	14% (1)
E. coli spp. % (*n*)	0% (0)	14% (1)
Total	100% (6)	100% (7)

Table 4 Catheter-associated urinary tract infection rates stratified by length of participation of the intensive care units in the International Nosocomial Infection Control Consortium. Poisson regression analysis.

Months since joining INICC	ICU, *n*	UC-days, *n*	CAUTI, *n*	Crude CAUTI rate/1000 UC-days	IRR accounting for clustering by ICU	*P*-value
1–3 months (baseline)	4	819	9	11.0	1.0	–
4–12 months	4	2619	8	3.05	0.3 (0.11–0.72)	0.008
Second year	2	697	3	4.3	0.26 (0.05–1.34)	0.108
Third year	2	1018	0	0.0	0.0 (–)	0.999
Fourth year	1	3454	10	2.9	0.13 (0.04–4.2)	0.0001

INICC, International Nosocomial Infection Control Consortium; ICU, intensive care unit; CAUTI, catheter-associated urinary tract infection; UC, urinary catheter; IRR, incidence-rate ratio.

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Discussion

The baseline rate of CAUTIs determined in this study (11.0 per 1000 UC-days) was 9-fold higher than the US rate of 1.5 CAUTI per 1000 UC-days, as determined by the CDC/NSHN [24], and 5-fold higher than the 2.5 CAUTI rate determined by the Krankenhaus Infektions Surveillance System (KISS) [25].

In comparison with pooled CAUTI rates from developing countries, our CAUTI baseline rate was higher than that listed in the fourth international INICC report published in 2012 (6.3 CAUTIs per 1000 UC-days) [26]. In the few studies addressing the burden of CAUTIs in the Philippines, the CAUTI rate in our study was higher than the rate reported in another study conducted in the Philippines (4.2 CAUTIs per 1000 UC-days) [11].

In studies performed by INICC member hospitals, it was determined that the implementation of a multi-dimensional approach for CAUTI — which includes a bundle of interventions, education, outcome and process surveillance, feedback of CAUTI rates, and performance feedback — resulted in significant reductions in CAUTI rates (21.3 vs. 12.39 CAUTIs per 1000 UC-days) [27], including rates of AICUs (7.86 vs. 4.95 CAUTIs per 1000 UC-days) [28] and of pediatric ICUs (5.9 vs. 2.6 CAUTIs per 1000 UC-days) [29].

The INICC multidimensional approach for controlling CAUTI included the following elements. First, an infection prevention bundle was implemented based on the guidelines published by SHEA and IDSA [19], which provide evidence-based recommendations and cost-effective infection control measures that can be feasibly adapted to the ICU setting in developing countries. Second, HCWs were educated in infection preventive measures. Third, CAUTI outcomes were monitored by applying the definitions for CAUTI developed by the US CDC/NHSN [21,22]. Fourth, CAUTI processes were monitored for compliance with easily measurable infection control measures, including HH performance. Fifth, feedback was provided on CAUTI rates. Sixth, performance feedback was given on process surveillance, particularly by reviewing and discussing chart results at monthly infection control meetings.

In our study, some patient characteristics, such as surgical stay, pulmonary disease, abdominal surgery, cancer, endocrine metabolic diseases, renal impairment, and immune compromise, were similar, as was UC mean duration; these characteristics showed similar patient intrinsic risk rates in both study phases. However, the mean age of patients and the proportion of women were higher during Phase II, meaning that the patient intrinsic risks were higher in the intervention period because female gender and older age have been identified as risk factors for CAUTI [30]. A multivariate analysis reviewed by Salgado et al. reported the five risk factors associated with the later development of CAUTI: (1) duration of catheterization, (2) catheter care violations, (3) absence of systemic antibiotics, (4) female gender, and (5) older age [31].

During the implementation of the INICC multidimensional approach, we noted improvements in process surveillance rates, with higher HH compliance and improved compliance with other measures, such as correct positioning of the UC (without obstructing the urine flow), which improved from 41.56% to 88.84%, and hanging of the collecting bag (to avoid urine reflux), which improved from 41.56% to 92.88% in Phase II. During the study period, the high CAUTI rate at baseline was reduced from 11.0 to 2.66 per 1000 UC-days, showing a 76% reduction in CAUTI rate and evidencing the effectiveness of the applied multidimensional approach.

Regarding the microorganism profile, we identified a predominance of *Candida* spp. during both periods, which is similar to other studies conducted in limited-resource countries [26,32—34].

Study limitations

This study has many limitations. First, our findings are not to be generalized to all ICU patients from the Philippines. Moreover, the inclusion of more ICUs would have allowed clustering-randomizing and possibly the analysis of intervention effects independently from external confounders. Additionally, the number of documented CAUTIs is small, which might be due to a local patient selection process for ICU admission, and at the beginning of the study period, there might have been a Hawthorne effect on our study results. However, after more than 4 years of continuous intervention with regular monitoring, the potential Hawthorne effect is certainly diluted, as behavior is gradually internalized as a social norm. In this study, it was shown that a multidimensional approach is fundamental to understand and fight the occurrence of CAUTIs in the AICU setting in the Philippines. Second, the 3-month baseline period was short and might have overestimated the effect of the intervention. Nevertheless, during the baseline period, the sample size was large enough, and the confidence intervals for the baseline rate were

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narrow. In addition, this length of baseline period is common in the scientific literature. Third, we did not count on the necessary resources to collect more data on process surveillance and measure compliance with all of the elements included in our bundle. Therefore, we could not evaluate the implications of individual interventions or other contextual factors related to the AICUs or hospitals. These data would have greatly contributed to advancing the knowledge of quality improvement in this setting of hospitals in the Philippines and to providing an accurate description of the successful results of our approach. Nevertheless, our main goal was to reduce the high baseline CAUTI rates in our ICUs, and although our interventions were inexpensive, individual evaluations would have required more allocation of time, contributing to unnecessary harm for ICU patients. Fortunately, from January 2012, we have been able to collect all of this process surveillance data.

Conclusions

This study is the first multicenter study to report a substantial reduction in CAUTI rates in the AICU setting in the Philippines, demonstrating that this type of infection control approach is successful. Although some patients' intrinsic risks were higher during the intervention period, a multidimensional approach to CAUTI preventive measures, including improved compliance, resulted in significant reductions in CAUTI incidence.

It is worth highlighting that the reduction in CAUTI rates does not derive from surveillance itself. This systematically collected data should serve to guide healthcare professionals in their strategies for improvement of patient care practices, which is facilitated by performance feedback, as demonstrated in several previous studies conducted in limited-resource countries [27–29].

The preventive strategies that were proven effective in the INICC ICUs in the Philippines can promote a wider acceptance of infection control programs in hospitals, leading to significant CAUTI reductions worldwide. Within the INICC network, investigators are provided with training and the methodological tools to perform outcome and process surveillance and to implement effective infection prevention programs. Furthermore, the publication of these findings contributes to the relevant scientific evidence-based literature from developing countries. Accordingly, every hospital is invited to participate in the INICC project, which was set up to respond to the compelling need in the developing world to significantly prevent, control, and reduce the incidence of CAUTIs and their adverse effects.

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Conflict of interest

All authors report no conflicts of interest related to this article. Every hospital's Institutional Review Board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

Competing interests

None declared.

Ethical approval

Not required.

Author contributions

Victor D. Rosenthal is responsible for idea, conception and design, software development, assembly of data, analysis and interpretation of the data, epidemiological analysis, statistical analysis, administrative, technical, and logistic support, drafting of the article and all authors are responsible for critical revision of the article for important intellectual content, final approval of the article, provision of study patients and collection of data.

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