Journal of Microbiology, Immunology and Infection (2017) 50, 464—470

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jmii.com

Original Article

Implementation of a national bundle care program to reduce catheter-associated urinary tract infection in high-risk units of hospitals in Taiwan

Chih-Cheng Lai [a], Chun-Ming Lee [b,c,d,e,f], Hsiu-Tzy Chiang [f], Ching-Tzu Hung [g], Ying-Chun Chen [h], Li-Hsiang Su [i], Zhi-Yuan Shi [j], Jein-Wei Liu [k], Chang-Pan Liu [c,f], Min-Chi Lu [l,m], Yin-Ching Chuang [n], Wen-Chien Ko [o,p], Shu-Hui Tseng [q], Yen-Hsu Chen [g,r,s,**], Po-Ren Hsueh [t,u,*] for the Infection Control Society of Taiwan

[a] Department of Intensive Care Medicine, Chi Mei Medical Center, Liouying, Tainan, Taiwan
[b] Department of Internal Medicine, St. Joseph's Hospital, Yunlin County, Taiwan
[c] Division of Infectious Disease, Department of Internal Medicine, MacKay Memorial Hospital, Taipei, Taiwan
[d] MacKay Junior College of Medicine, Nursing, and Management, Taipei, Taiwan
[e] MacKay Medical College, New Taipei City, Taiwan
[f] Infection Control Center, MacKay Memorial Hospital, Taipei, Taiwan
[g] Center of Infection Control, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[h] Center of Infection Control, Taichung Veterans General Hospital, Taichung, Taiwan
[i] Center of Infection Control, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan
[j] Department of Internal Medicine, Taichung Veterans General Hospital, Taichung, Taiwan
[k] Department of Internal Medicine, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan
[l] Division of Infectious Diseases, Department of Internal Medicine, China Medical University Hospital, Taichung, Taiwan
[m] Department of Microbiology and Immunology, School of Medicine, China Medical University, Taichung, Taiwan
[n] Department of Internal Medicine, Chi Mei Hospital, Liouying, Taiwan
[o] Department of Internal Medicine, National Cheng Kung University Medical College and Hospital, Tainan, Taiwan
[p] Center of Infection Control, National Cheng Kung University Medical College and Hospital, Tainan, Taiwan

* Corresponding author. Department of Laboratory Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, No. 7 Chung-Shan South Road, Taipei 100, Taiwan.
** Corresponding author. Division of Infectious Diseases, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan.
E-mail addresses: infchen@gmail.com (Y.-H. Chen), hsporen@ntu.edu.tw (P.-R. Hsueh).

http://dx.doi.org/10.1016/j.jmii.2017.01.006

[q] Center for Disease Control, Ministry of Health and Welfare, Taiwan
[r] Division of Infectious Diseases, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[s] School of Medicine, Graduate Institute of Medicine, Sepsis Research Center, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
[t] Department of Laboratory Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan
[u] Department of Internal Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan

Received 20 December 2016; received in revised form 5 January 2017; accepted 5 January 2017
Available online 26 June 2017

KEYWORDS
Bundle care;
Catheter-associated urinary tract infection;
Surveillance

Abstract *Background/purpose:* This study was intended to investigate the impact of implementation of catheter-associated urinary tract infection (CA-UTI) bundle care on the incidence of CA-UTI in high-risk units.
Methods: Thirteen high-risk units, including medical ($n = 5$), surgical ($n = 3$), cardiac intensive care units ($n = 2$), respiratory care centers ($n = 2$), and respiratory care ward ($n = 1$) were included in this quality-improvement project. This study was divided into pre-intervention phase (from January 1 to July 31) and post-intervention phase (from August 1 to October 31) in 2013.
Results: The incidence of CA-UTI decreased by 22.7%, from 3.86 to 2.98 per 1000 catheter-days (95% confidence interval, 0.65–0.82; $p < 0.0001$) before and after the introduction of the CA-UTI bundle. Among 66 episodes of culture-proven CA-UTIs, *Candida* spp. were the most common pathogens ($n = 17$, 25.8%), followed by *Escherichia coli* ($n = 10$, 15.2%). For the seven elements of the insertion bundle, the compliance was the lowest for cleaning of the perineum, followed by hand hygiene. The overall compliance rates of the insertion bundle were 93.4%, 99.5%, and 96.3% in medical centers, regional hospitals, and district hospital, respectively. For the six elements of the maintenance bundle, the compliance was the lowest for daily review of the need of a Foley catheter. The overall compliance rates of the maintenance bundle were 95.7%, 99.9%, and 99.9% in medical centers, regional hospitals, and district hospital, respectively.
Conclusions: The implementation of CA-UTI bundle care successfully reduced CA-UTI in Taiwanese high-risk units. A process surveillance checklist can be helpful for understanding which parts of the bundle care require improvements.

Introduction

Catheter-associated urinary tract infection (CA-UTI) is a common type of device-associated infection in the intensive care unit (ICU).[1–7] In developing countries, such as Argentina, Brazil, Colombia, Mexico, and Peru, CA-UTIs reportedly comprise 29% of all device-associated infections, with an incidence of 8.9 cases (range, 1.7–12.8 cases) per 1000 catheter-days.[1] In a national report from Turkey, the rate of CA-UTI was 7.5 per 1000 urinary catheter-days, with a crude rate of extra mortality of 10.5% in the ICU.[5] In India, the pooled rate of CA-UTI from the surveillance of 40 hospitals was 2.1 per 1000 urinary catheter-days, and caused an extra mean length of stay of 10 days.[7] In the US, the report of the National Healthcare Safety Network disclosed that the pooled rate of CA-UTI in the critical care unit ranged from 1.3 to 4.5 per 1000 catheter-days.[3] Taken together, these findings indicate the CA-UTI has become a great threat to patient safety worldwide, and emphasize the importance of active infection control programs for surveillance of infection. Most importantly, they suggest that we need to develop and implement effective strategies for preventing CA-UTI.

Recently, several strategies, such as avoiding unnecessary urinary catheters, using aseptic procedures by trained personnel, including during the procedure of catheter insertion, and early removal of the catheter unless otherwise indicated, have been suggested.[2,4,6] Although most studies have demonstrated that the implementation of such bundle cares can effectively decrease the development of CA-UTI,[8–16] Saint et al. conversely reported that the rates of CA-UTI in ICUs did not change after the implementation of a national prevention program in the US.[17] These findings may indicate different impacts of CA-UTI bundles on the rate of CA-UTI in different settings, and further investigation is warranted to clarify the effect of such CA-UTI bundles.

According to the 2012 surveillance data in Taiwan, the rates of CA-UTI among ICUs of medical centers and regional hospitals were 3.5 and 2.0 per 1000 catheter-days, respectively. Thus, a government-led force combined with a professional organization promoting urinary catheter care quality is imperative; the Centers for Disease Control, Taiwan (Taiwan CDC) has implemented a national action plan to reduce CA-UTI in Taiwan since 2013. In this pilot study of a national project, a CA-UTI bundle care was implemented in 13 high-risk units in medical centers and regional and district hospitals, and the effect of the CA-UTI bundle on the rate of CA-UTI was assessed.

Methods

Setting and participating units

This program represented a national collaboration of professional societies, healthcare workers, Taiwan CDC, and academic researchers. Initially, infection control experts in Taiwan, including infection specialists, intensivists, infection control nurses, clinical nurses, and one epidemiologist, were recruited in the design of this study. After obtaining the approval of the Institutional Review Board of each investigation site, this national study was carried out in seven medical centers, three regional hospitals, and one district hospital. A total of 13 high-risk units, including five medical ICUs (MICUs), three surgical ICUs (SICUs), two cardiac ICUs (CICUs), two respiratory care centers (RCCs), and one respiratory care ward (RCW), were included in this quality-improvement project. The high-risk units contained 196 beds. The bed numbers of each type of units and hospitals are shown in Table 1. Among the 196 beds, the MICUs accounted for 65.7% ($n = 70$), followed by the SICUs ($n = 53$, 27.0%) and RCCs ($n = 30$, 15.3%). Seven high-risk units, including four MICUs, two SICUs, and one RCW, had experience of implementing their own CA-UTI bundle care within their units prior to this study. This study was divided into the pre-intervention phase (between January 1, 2013 and July 31, 2013) and post-intervention phase (between August 1, 2013 and October 31, 2013).

Table 1 Baseline characteristics of the high-risk units enrolled in this study.

Region of Taiwan	Type of hospital	Type of unit	Number of beds	Previous experience of bundle care
North	Medical center	RCC	10	No
North	Medical center	CICU	12	No
North	Medical center	MICU	8	Yes
North	Medical center	CICU	10	No
Middle	Medical center	MICU	24	Yes
Middle	Medical center	SICU	25	Yes
South	Medical center	MICU	13	Yes
South	Medical center	RCC	20	No
East	Medical center	MICU	10	No
North	Regional hospital	MICU	15	Yes
South	Regional hospital	SICU	17	Yes
South	Regional hospital	SICU	11	No
Middle	District hospital	RCW	21	Yes

ICU, intensive care unit; CICU, cardiac ICU; MICU, medical ICU; RCC, respiratory care center; RCW, respiratory care ward; SICU, surgical ICU.

Study interventions

After several expert meetings, a national evidence-based guideline of the CA-UTI bundle was developed. The bundle included two parts. The first part was the insertion bundle, which included seven components: hand hygiene, cleaning of the perineum, aseptic insertion, correct disinfection method, aseptic connection between the Foley catheter and urinary bag, appropriate fixation of the Foley catheter, and maintenance of a sterile closed drainage system. The second part was the maintenance bundle, which included daily review of the indications for the urinary catheter to ensure timely removal of unnecessary catheters, hand hygiene, avoiding filling of the urinary bag to >80%, appropriate fixation of the Foley catheter, position of the urinary bag kept below the urinary bladder, and maintenance of a sterile, closed, and patent drainage system.

Urine culture results for patients with CA-UTI during the post-intervention period were also analyzed. Identification of organisms from urine cultures was based on conventional identification methods. Susceptibilities of the isolates were determined by using the disk diffusion method or one of two commercial susceptibility testing systems: Phoenix (Becton—Dickinson, Microbiology Systems, Sparks, MD, USA) or Vitek 2 (bioMérieux, Marcy l'Etoile, France). The susceptibility results were interpreted according to the guidelines by the Clinical and Laboratory Standards Institute.[18]

Definitions

CA-UTI was defined according to the Centers for Disease Control and Prevention guidelines.[19,20] All participating units provided the total numbers of CA-UTIs, catheter-days, and patient-days. The incidence of CA-UTI was defined as the episodes of CA-UTI per 1000 catheter-days. In addition, during the expert meetings, two checklists regarding the insertion and maintenance bundle were created as a reference for assessment of the compliance of each CA-UTI intervention. Process surveillance through the use of checklists was developed to assess the compliance of the insertion and maintenance bundle practices, and compliance was defined as the ratio of the number of each bundle performed to the number of catheter insertions and maintenances. During the post-intervention phase, the compliance to the CA-UTI insertion and maintenance bundles was observed.

Statistical analysis

We compared the CA-UTI incidence of the pre- and post-intervention phases, and calculated the percentage change in the CA-UTI incidence between the post- and pre-intervention phases by dividing the post-intervention CA-UTI incidence by the CA-UTI incidence during the pre-intervention phase $\times$ 100%. The results of this analysis were presented as the incidence rate ratio (IRR) and 95% confidence interval (CI) with accompanying p-values. Analyses were completed with Microsoft Excel 2013 and a p value of <0.05 was considered statistically significant.

Results

Incidences of CA-UTI in the pre- and post-intervention phases

The incidence of CA-UTI decreased by 22.7%, from 3.86 per 1000 catheter-days to 2.98 per 1000 catheter-days (IRR, 0.73; 95% CI, 0.65–0.82; $p < 0.0001$) (Table 2). Among the patients with CA-UTI in the post-intervention phase, 24 had used urinary catheters for more than one week, and the average duration of catheter use was 6.1 days. Among 66 episodes of culture-proven CA-UTIs, *Candida* spp. were the most common pathogens ($n = 17$, 25.8%), followed by *Escherichia coli* ($n = 10$, 15.2%) (Table 3). Additionally, 11 pathogens were multidrug-resistant organisms, including seven extended-spectrum β-lactamase-producing organisms (six *E. coli* and one *Klebsiella oxytoca* isolate), three carbapenem (imipenem or meropenem)-resistant isolates (two *Acinetobacter calcoaceticus–baumannii* complex and one *Pseudomonas aeruginosa* isolate), and one vancomycin-resistant *Enterococcus faecium*.

Incidences of CA-UTI according to the different types of hospitals and high-risk units

Among the different type of hospitals, the incidence of CA-UTI was the highest for medical centers and lowest in the district hospital. In the medical centers, the incidence of CA-UTI decreased from 3.81 per 1000 catheter-days in the pre-intervention phase to 3.11 per 1000 catheter-days in the post-intervention phase (IRR, 0.75; 95% CI, 0.65–0.86; $p < 0.0001$). In the regional hospitals, the incidence of CA-UTI decreased from 3.86 per 1000 catheter-days in the pre-intervention phase to 3.00 per 1000 catheter-days (IRR, 0.89; 95% CI, 0.70–1.12; $p = 0.352$) in the post-intervention phase. In the district hospital, the incidence of CA-UTI decreased from 4.31 per 1000 catheter-days in the pre-intervention phase to 1.98 per 1000 catheter-days in the post-intervention phase (IRR, 0.31; 95% CI, 0.20–0.49; $p < 0.0001$).

Among the different types of ICU, the changes in the incidences of CA-UTI differed. For the MICU, the incidence of CA-UTI increased from 2.56 per 1000 catheter-days in the pre-intervention phase to 3.36 per 1000 catheter-days in the post-intervention phase (IRR, 1.37; 95% CI, 1.11–1.70; $p = 0.004$). For CICUs, the incidence of CA-UTI decreased from 4.43 per 1000 catheter-days in the pre-intervention phase to 1.95 per 1000 catheter-days in the post-intervention phase (IRR, 0.55; 95% CI, 0.42–0.72; $p < 0.0001$). For RCCs, the incidence of CA-UTI decreased from 9.78 per 1000 catheter-days in the pre-intervention phase to 6.16 per 1000 catheter-days in the post-intervention phase (IRR, 0.65; 95% CI, 0.49–0.86; $p = 0.003$). For the RCW, the incidence of CA-UTI decreased from 4.31 per 1000 catheter-days in the pre-intervention phase to 1.98 per 1000 catheter-days (IRR, 0.31; 95% CI, 0.20–0.49; $p < 0.0001$). In SICUs, the incidence of CA-UTI decreased from 4.00 per 1000 catheter-days in the pre-intervention phase to 2.90 per 1000 catheter-days (IRR, 0.68; 95% CI, 0.54–0.87; $p = 0.002$).

Table 2 Changes in the rates of catheter-associated urinary tract infection (CA-UTI).

	Episodes of CA-UTI		Catheter-days		Incidence of CA-UTI (cases per 1000 catheter-days)		Change in incidence (%)	Incidence rate ratio	95% confidence interval	p Value
	Pre-intervention phase	Post-intervention phase	Pre-intervention phase	Post-intervention phase	Pre-intervention phase	Post-intervention phase				
Type of hospital										
Medical center	130	59	34,140	18,995	3.81	3.11	−18.4	0.75	0.65–0.86	<0.0001
Regional hospital	68	27	17,605	8999	3.86	3.00	−22.3	0.89	0.70–1.13	0.352
District hospital	15	5	3477	2525	4.31	1.98	−54.1	0.31	0.20–0.49	<0.0001
Type of unit										
CICU	41	9	9253	4620	4.43	1.95	−56.0	0.55	0.42–0.72	<0.0001
MICU	50	32	19,476	9510	2.56	3.36	+31.1	1.37	1.11–1.70	0.004
RCC	25	9	2556	1462	9.78	6.16	−37.1	0.65	0.49–0.86	0.003
RCW	15	5	3477	2525	4.31	1.98	−54.1	0.31	0.20–0.49	<0.0001
SICU	82	36	20,460	12,402	4.00	2.90	−27.6	0.68	0.54–0.87	0.002
Overall	213	91	55,222	30,519	3.86	2.98	−22.7	0.73	0.65–0.82	<0.0001

ICU, intensive care unit; CICU, cardiac ICU; MICU, medical ICU; RCC, respiratory care center; RCW, respiratory care ward; SICU, surgical ICU.

Table 3 Microbiology results of the 66 culture-proven catheter-associated urinary tract infections.

Pathogens	Number (%) of isolates (n = 66)
Candida spp.	18 (27.3)
C. albicans	9 (13.6)
C. glabrata	1 (1.5)
Other *Candida* spp. (not specified)	8 (12.1)
E. coli	16 (24.2)
Enterococcus spp.	11 (16.7)
E. faecalis	7 (10.6)
E. faecium	3 (4.5)
Other *Enterococcus* spp.	1 (1.5)
Pseudomonas spp.	10 (15.2)
P. aeruginosa	9 (13.6)
P. putida	1 (1.5)
Proteus mirabilis	3 (4.5)
Acinetobacter calcoaceticus—baumannii complex	2 (3.0)
Staphylococcus spp.	2 (3.0)
S. aureus	1 (1.5)
S. epidermidis	1 (1.5)
Stenotrophomonas maltophilia	1 (1.5)
Klebsiella oxytoca	1 (1.5)
Citrobacter spp.	1 (1.5)
Trichosporon spp.	1 (1.5)
Multidrug-resistant organisms[a]	11 (16.7)

[a] Including seven extended-spectrum β-lactamase-producing organisms (six *E. coli* and one *K. oxytoca* isolate), three carbapenem-resistant isolates (two *A. calcoaceticus—baumannii* complex and one *P. aeruginosa* isolate), and one vancomycin-resistant *E. faecium*.

Table 4 Compliance rates of the catheter-associated urinary tract infection bundle care.

	Rates (%) of compliance for bundle care	
	Insertion bundle	Maintenance bundle
Type of hospital		
Medical center	93.4	95.4
Regional hospital	99.5	99.9
District hospital	96.3	99.9
Type of unit		
CICU	87.2	99.8
MICU	98.1	89.7
RCC	95.6	99.8
RCW	96.3	99.9
SICU	98.7	99.1
Overall	94.9	97.2

ICU, intensive care unit; CICU, cardiac ICU; MICU, medical ICU; RCC, respiratory care center; RCW, respiratory care ward; SICU, surgical ICU.

Compliance of the CA-UTI bundle care

For the seven elements of the insertion bundle, the compliance was the lowest for cleaning of the perineum, followed by hand hygiene. The overall compliance rates of the insertion bundle were 93.4%, 99.5%, and 96.3% in the medical centers, regional hospitals, and district hospital, respectively. According to the different types of ICUs, the compliance of the insertion bundle was the highest for the SICU (98.7%), followed by the MICU (98.1%), RCW (96.3%), RCC (95.6%), and CICU (87.2%). For the six elements of the maintenance bundle, the compliance was the lowest for daily review of the need of a Foley catheter. The overall compliance rates of the maintenance bundle were 95.7%, 99.9%, and 99.9% in the medical centers, regional hospitals, and district hospital, respectively. According to the different type of ICUs, the compliance rates of the maintenance bundle were the highest for the RCW (99.9%), followed by the SICU (99.1%), RCC (99.8%), CICU (99.8%), and MICU (89.7%) (Table 4).

Discussion

In this study, we found that implementation of a CA-UTI bundle through a national program could effectively reduce the rates of CA-UTI in high-risk units in Taiwan. The incidence of CA-UTI decreased by 22.7%, from 3.86 at baseline to 2.98 per 1000 catheter-days after intervention. This finding is contrary to a recent US study that the CA-UTI rates in 373 ICUs remained unchanged (2.48 per 1000 catheter-days at baseline and 2.50 per 1000 catheter-day at the end of the sustainability period; IRR, 1.01; 95% CI, 0.87—1.17; p = 0.90).[17] However, several other reports[12—14] showed consistent findings with those of the present study. In one ICU in Lebanon, the rate of CA-UTI was 13.07 per 1000 catheter-days in the initial phase, and was decreased by 83% after a multidimensional infection control approach, to 2.21 per 1000 catheter-days (risk ratio, 0.17; 95% CI, 0.06—0.5; p = 0.0002).[12] In 13 ICUs in Turkey, the rate of CA-UTI was significantly decreased from 10.63 per 1000 catheter-days initially to 5.65 per 1000 catheter-days after intervention (relative risk, 0.53; 95% CI, 0.4—0.7; p = 0.0001).[13] In four ICUs in the Philippines, the rate of CA-UTI was decreased by 76% from 11.0 per 1000 catheter-days at baseline to 2.66 per 1000 catheter-days during the intervention (rate ratio, 0.24; 95% CI, 0.11—0.53; p = 0.0001).[14] Even in pediatric ICUs, implementing a multidimensional infection control approach was found to be associated with a significant reduction in the CA-UTI rate in one previous study.[21] Thus, overall, most studies,[12,13,15,21] including our investigation, support the effectiveness of a CA-UTI bundle on reducing CA-UTI in the ICU setting.

In this study, we enrolled high-risk units from different types of hospitals, including medical centers, regional hospitals, and a district hospital. We found that the overall incidence of CA-UTI decreased after the implementation of the CA-UTI bundle, with most types of hospitals showing consistent trends. However, the decrease did not reach statistical significance in two regional hospitals. Based on the feedback from these two hospitals, we found that, after the implementation of the intervention, the Foley catheters of most CA-UTI cases were inserted in the ward or emergency department. However, except the two investigation sites, the CA-UTI bundle was not applied for the other units. Therefore, the cause of CA-UTIs in these two units may be the result from improper insertion or care of the urinary catheter in other sites that had not implemented the bundle. This reminds us that the care of a urinary catheter in the hospital can be performed in many units. Thus, it is not enough to simply implement CA-UTI bundle care in one single unit, and we should pay more effort to ensuring implementation in the whole hospital.

In contrast to most units, which showed decreasing incidences of CA-UTI after the intervention, we found that the incidence of CA-UTI was significantly increased in the MICUs. One explanation may be the relatively low compliance of the maintenance bundle in the MICUs. In the MICUs, the compliance of the maintenance bundle was only 89.7%, which was much lower than in the other units (>97%). Among the six components of the maintenance bundle, the compliance of the cleaning of the perineum (88.4%) was the lowest in the MICUs. Although we did not demonstrate the correlation between CA-UTI cases and the cleaning of the perineum in this study, this finding suggests that actions should be taken to improve the perineum cleaning during this quality-improvement project. This may help us decrease the incidence of CA-UTI in MICUs. In addition, this study emphasizes the importance of the checklist as a tool of performance surveillance.

Finally, we analyzed the microbiology findings of CA-UTI after the implementation of the bundle care. Although we did not collect data on the microbiological distribution of CA-UTIs before the intervention, and could thus not determine the differences between before and after intervention, it is noteworthy that we found that *Candida* species were the most common pathogens and that a substantial portion of bacterial pathogens appeared to be multidrug-resistant. However, further large-scale studies are warranted to confirm our findings.

This study had two main limitations. First, we did not collect the detailed clinical characteristics of the patients in these high-risk units or information regarding whether other infection control measures were implemented in these units during the study period. Thus, we could not exclude possible confounding factors that may have affected the impact of the CA-UTI bundle care in this study. Second, the number of study subjects was limited and the period of evaluation was too short in this study. In the future, we need to enroll more units and include a longer follow-up duration to assess the effectiveness of this program. However, as a pilot study including different types of hospitals and units from different regions of Taiwan, this investigation still provided useful information for establishing an infection control policy in Taiwan.

In conclusion, the implementation of CA-UTI bundle care could successfully reduce CA-UTI in most high-risk units in Taiwan. The checklist for process surveillance can help us understand which part of the bundle care we need to improve. Finally, *Candida* spp. and multidrug-resistant bacteria were the most common CA-UTI pathogens after the implementation of the bundle care.

Conflict of interest

There is no conflict of interest.

References

1. Rosenthal VD, Maki DG, Salomao R, Moreno CA, Mehta Y, Higuera F, et al. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. *Ann Intern Med* 2006;**145**:582–91.
2. Chenoweth CE, Gould CV, Saint S. Diagnosis, management, and prevention of catheter-associated urinary tract infections. *Infect Dis Clin North Am* 2014;**28**:105–19.
3. Dudeck MA, Horan TC, Peterson KD, Allen-Bridson K, Morrell G, Anttila A, et al. National Healthcare Safety Network report, data summary for 2011, device-associated module. *Am J Infect Control* 2013;**41**:286–300.
4. 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;**31**:319–26.
5. Leblebicioglu H, Erben N, Rosenthal VD, Atasay B, Erbay A, Unal S, et al. International Nosocomial Infection Control Consortium (INICC) national report on device-associated infection rates in 19 cities of Turkey, data summary for 2003–2012. *Ann Clin Microbiol Antimicrob* 2014;**13**:51.
6. Lo E, Nicolle LE, Coffin SE, Gould C, Maragakis LL, Meddings J, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol* 2014;**35**:464–79.
7. Mehta Y, Jaggi N, Rosenthal VD, Kavathekar M, Sakle A, Munshi N, et al. Device-associated infection rates in 20 cities of India, data summary for 2004–2013: findings of the International Nosocomial Infection Control Consortium. *Infect Control Hosp Epidemiol* 2016;**37**:172–81.
8. Kachare SD, Sanders C, Myatt K, Fitzgerald TL, Zervos EE. Toward eliminating catheter-associated urinary tract infections in an academic health center. *J Surg Res* 2014;**192**:280–5.
9. Cheng WY, Lin HL, Lin YH, Lai CC, Chao CM. Achieving zero catheter-associated urinary tract infections in a neurosurgery intensive care unit. *Infect Control Hosp Epidemiol* 2014;**35**:746–7.
10. Davis KF, Colebaugh AM, Eithun BL, Klieger SB, Meredith DJ, Plachter N, et al. Reducing catheter-associated urinary tract infections: a quality-improvement initiative. *Pediatrics* 2014;**134**:e857–64.
11. Meddings J, Rogers MA, Krein SL, Fakih MG, Olmsted RN, Saint S. Reducing unnecessary urinary catheter use and other strategies to prevent catheter-associated urinary tract infection: an integrative review. *BMJ Qual Saf* 2014;**23**:277–89.
12. 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;**17**:e686–90.
13. 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;**41**:885–91.
14. 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;**6**:389—99.

15. Rosenthal VD, Todi SK, Alvarez-Moreno C, Pawar M, Karlekar A, Zeggwagh AA, et al. Impact of a multidimensional infection control strategy on catheter-associated urinary tract infection rates in the adult intensive care units of 15 developing countries: findings of the International Nosocomial Infection Control Consortium (INICC). *Infection* 2012;**40**:517—26.
16. Saint S, Greene MT, Kowalski CP, Watson SR, Hofer TP, Krein SL. Preventing catheter-associated urinary tract infection in the United States: a national comparative study. *JAMA Intern Med* 2013;**173**:874—9.
17. Saint S, Greene MT, Krein SL, Rogers MA, Ratz D, Fowler KE, et al. A program to prevent catheter-associated urinary tract infection in acute care. *N Engl J Med* 2016;**374**:2111—9.
18. Clinical and Laboratory Standard Institute (CLSI). *Performance standards for antimicrobial susceptibility testing; 23rd informational supplement* [CLSI document M100-MS23]. Wayne, PA, USA: CLSI; 2013.
19. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. *Clin Infect Dis* 2010;**50**:625—63.
20. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008;**36**:309—32.
21. Rosenthal VD, Ramachandran B, Duenas 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;**33**:696—703.