



Catheter-related bloodstream infection: burden of disease in a tertiary hospital

H.R. Martínez-Morel^{a,b}, J. Sánchez-Payá^{a,*}, M.J. Molina-Gómez^a,
P. García-Shimizu^a, V. García Román^a, C. Villanueva-Ruiz^a,
M. González-Hernández^a, A. Nolasco-Bonmatí^b

^aDepartment of Preventive Medicine, Alicante University General Hospital, Alicante, Spain

^bDepartment of Community Nursing, Preventive Medicine and Public Health and History of Science, Alicante University, Alicante, Spain

ARTICLE INFO

Article history:

Received 23 May 2013

Accepted 22 April 2014

Available online 15 May 2014

Keywords:

Catheter-related bloodstream infection

Central venous catheter

Primary bloodstream infection

Surveillance

Infection control



CrossMark

SUMMARY

Background: Surveillance programmes have become the most effective tool for controlling catheter-related bloodstream infections (CRBSI). However, few studies have investigated programmes covering all hospital settings.

Aim: To describe the results of a control and prevention programme for CRBSI based on compliance with recommendations for insertion and maintenance, using annual burden of disease in a tertiary level hospital.

Methods: A CRBSI control and prevention programme involving all hospital settings was implemented. The programme consisted of CRBSI surveillance, direct observation of insertion and maintenance of catheters to determine performance, and education for healthcare workers.

Findings: In total, 2043 short-term catheters were inserted in 1546 patients for 18,570 catheter-days, and 279 long-term catheters were inserted in 243 patients for 40,440 catheter-days. The annual incidence density was 5.98 (first semester 6.40, second semester 5.64) CRBSI per 1000 catheter-days for short-term catheters, and 0.57 (first semester 0.66, second semester 0.43) CRBSI per 1000 catheter-days for long-term catheters. One hundred and forty insertion procedures were observed, with an average insertion time of 13 (standard deviation 7) min. Compliance with recommendations was as follows: hand hygiene, 86.8%; use of alcoholic chlorhexidine solution for skin disinfection, 35.5%; use of mask, 93.4%; use of gloves, 98.7%; use of gown, 75.0%; use of sterile cloth, 93.8%; use of cap, 92.2%; bandage application, 62.7%; and use of aseptic technique, 89.5%. Forty-five maintenance procedures were observed, and compliance rates were as follows: hand hygiene, 42.1%; use of gloves, 78.1%; and port disinfection with alcoholic chlorhexidine solution, 32.5%.

Conclusion: The CRBSI control and prevention programme implemented at the study hospital has decreased the rate of CRBSI, provided important information about the total burden of disease, and revealed possible ways to improve interventions in the future.

© 2014 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.

* Corresponding author. Address: Unidad de Epidemiología, Servicio de Medicina Preventiva, Hospital General Universitario de Alicante, c/ Pintor Baeza, 12, 03010 Alicante, Spain. Tel.: +34 965933574; fax: +34 965352552.

E-mail address: sanchez_jos@gva.es (J. Sánchez-Payá).

Introduction

Bacteraemia is among the top four causes of healthcare-associated infection, and is most commonly related to the use of central venous catheters.^{1–3} In Europe, the rate of catheter-related bloodstream infections in intensive care units (ICUs) is estimated to range between 1 and 4.2 per 1000 catheter-days,^{4,5} although it has been reported to reach 13.3 per 1000 catheter-days.⁶ Clinical guidelines for safe insertion and maintenance of intravascular catheters exist,^{7,8} but compliance is inadequate^{9–12} and there is wide variation in practice across hospitals.

The main tools for controlling catheter-related bloodstream infections are surveillance programmes and associated education campaigns for healthcare workers involved in catheter insertion or maintenance.^{13–19} Implementation of these programmes markedly reduces the rate of catheter-related bloodstream infections, and rates stay low in settings where programmes remain active.²⁰ Infection control strategies have been well studied in ICUs, mainly due to the high prevalence of use of central venous catheters in these units.^{21,22} However, the absolute number of patients with a central venous catheter is higher outside ICUs, and in some centres, the prevalence of catheter-related bloodstream infections is higher outside ICUs.^{23,24} Furthermore, risk factors for catheter-related bloodstream infections and control strategies are different outside ICUs,^{24,25} and some groups of patients outside ICUs, including those receiving parenteral nutrition, those on dialysis and those using tunnelled central venous catheters, require special precautions.

As a consequence, the evaluation of infection control programmes requires a systematic assessment of catheter-related bloodstream infections in different hospital settings.²⁶ This study aimed to describe the total annual burden of disease of catheter-related bloodstream infections in a tertiary level hospital, including all settings with patients with central venous catheters and other types of catheters; and to describe a control and prevention programme for catheter-related bloodstream infections based on measuring compliance with recommendations for the insertion and maintenance of central venous catheters.

Methods

Study population

A catheter-related bloodstream infection control and prevention programme, involving all hospital settings, was implemented in a tertiary university hospital. The hospital has 900 beds and 3000 healthcare workers, providing coverage to 300,000 people and serving as point of referral for almost two million people. The programme consisted of three main activities: surveillance of central venous catheters; observation of compliance with recommendations for insertion and maintenance of central venous catheters; and education for healthcare workers, distribution of leaflets about the recommendations, and feedback of the surveillance findings to the hospital settings after the first five months. Education courses were initiated with the programme and were delivered to groups of 10 healthcare workers on a three-weekly basis (60 min during work time). The education courses covered safe catheter handling, hand hygiene, barrier precautions and biomedical waste management.

Surveillance of catheter-related bloodstream infection

Surveillance included all patients with central venous catheters inserted at the Alicante University General Hospital between February 2009 and December 2009. The period from February to June 2009 was termed the 'first semester' and the period from July to December 2009 was termed the 'second semester'. All central venous catheters were included from insertion until removal, death of the patient or the diagnosis of catheter-related bloodstream infection. Catheters were defined as short term or long term based on intended life span. Short-term catheters were supported for a maximum of 90 days, and included Swan Ganz, epicutaneous, Sheldon, drum-cartridge and standard one-, two- or three-lumen catheters. Long-term catheters were skin tunnelled, and included Hickman, Port-A-Cath and Permcath catheters. Follow-up was extended to six months for long-term central venous catheters.

In both semesters, a nurse gathered information on a daily basis about all central venous catheters inserted at the hospital. Data on patient characteristics (age, sex, main diagnosis), intrinsic risk factors (obesity, malignancy, diabetes, neutropenia, burns, immunosuppression) and extrinsic risk factors (urinary catheter, peripheral line, nasogastric tube, arterial catheters, major surgery, chemotherapy, invasive procedures) for catheter-related bloodstream infection, catheter characteristics (insertion date, hospital setting, type of catheter, insertion site, number of lumens, urgent insertion) and presence of catheter-related bloodstream infection were collected. Catheter-related bloodstream infection was defined, in accordance with the criteria of the Centers for Disease Control and Prevention,⁷ as the presence of one or more positive blood cultures and a positive catheter tip culture, whereby the same organism (species and antibiogram) is isolated and not related to another site of infection. Two positive blood cultures or at least one blood culture and physician-instituted appropriate antimicrobial therapy were required in cases of possible skin contaminants. In borderline cases (e.g. colony count slightly below the limit), a systematic review of medical records was conducted, and the case was considered positive if catheter-related bloodstream infection was diagnosed and the patient underwent treatment with appropriate antibiotics. In the study hospital, all catheters with suspected infection are cultured routinely using a quantitative method. Incidence densities of catheter-related bloodstream infections were measured for the full year and then in each semester to assess changes over the year.

Measurement of compliance with effective, proven recommendations

Observation periods of 30–60 days were undertaken in each hospital setting (ICU, operating room, paediatric ICU, recovery room and radiology) to verify the insertion of central venous catheters, with at least one observation period performed in each semester. For each observed insertion procedure, a nurse checked compliance with recommended safety measures for insertion. The variables observed were: operator (staff or resident); insertion time; hand hygiene; use of alcoholic chlorhexidine solution; use of barrier methods (mask, sterile gown, sterile drapes, sterile gloves, cap); use of sterile dressings; use

of aseptic technique; and if all personnel who participated in the procedure had complied with the recommendations.

Observation periods lasting 2 h were undertaken in each inpatient unit to verify the maintenance of central venous catheters. Compliance with recommendations was checked each time a healthcare worker handled a central venous catheter. The variables recorded were: hand hygiene; use of gloves; and disinfection of ports with alcoholic chlorhexidine solution before handling.

Statistical analysis

Percentages were used to describe categorical variables, and means with standard deviations or medians with interquartile ranges (IQR) were used to describe quantitative variables. Independent variables and catheter-related bloodstream infection were compared by univariate analysis, using Chi-squared test for categorical variables, and Student's *t*-test or Mann-Whitney *U*-test for continuous variables. Incidence density was calculated for catheter-related bloodstream infection episodes per 1000 catheter-days, and incidence rate ratios with 95% confidence intervals were compared between the first and second semesters using Poisson regression analysis. $P < 0.05$ was taken to indicate statistical significance. Statistical Package for the Social Sciences Version 10 (SPSS Inc., Chicago, IL, USA) and Epidat Version 3.1 (Xunta de Galicia, Santiago de Compostela, Spain and Pan American Health Organization/World Health Organization, Washington, DC, USA) were used for statistical analyses.

Results

In total, 2043 short-term catheters were inserted in 1524 patients for 18,570 catheter-days, and 279 long-term catheters were inserted in 243 patients for 40,440 catheter-days.

Table I
Patient characteristics and risk factors for catheter-related bloodstream infection

	Short-term CVC		Long-term CVC	
Patients, <i>N</i>	1524		243	
Age in years, median (IQR)	60	(39–72)	51	(30–66)
Male sex, % (<i>N</i>)	61.2	(932)	56.8	(138)
Intrinsic risk factors, % (<i>N</i>)				
Obesity	7.2	(110)	4.5	(11)
Neoplasia	22.7	(346)	64.2	(156)
Neutropenia	1.3	(20)	18.1	(44)
Diabetes	18.9	(288)	18.1	(44)
Burns	0.9	(14)	0	(0)
Immunosuppression	3.1	(47)	14.4	(35)
Extrinsic risk factors, % (<i>N</i>)				
Urinary catheter	73.4	(1119)	9.9	(24)
Peripheral line	64.6	(985)	51.8	(126)
Nasogastric tube	51.1	(779)	5.3	(13)
Arterial catheter	52.6	(802)	4.5	(11)
Mechanical ventilation	20.3	(309)	3.3	(8)
Chemotherapy	5.9	(90)	43.2	(105)
Surgery	49.8	(759)	7.4	(18)

CVC, central venous catheter; IQR, interquartile range.

Characteristics of patients and risk factors for catheter-related bloodstream infection are summarized in Table I. Characteristics of both short- and long-term catheters are shown in Table II. For short-term catheters, the median duration of use was seven days (IQR four to 12 days). The most common catheter site was the jugular vein, followed by the subclavian and femoral veins. A standard three-lumen catheter was used most commonly in all hospital settings. Catheters inserted in the operating theatre by anaesthesiologists were removed sooner than catheters inserted in other units, and catheters inserted in interventional radiology remained in use for longer periods and were primarily inserted in internal medicine patients. For long-term catheters, the median duration of use was 183 days (IQR 109–184 days). The majority of long-term catheters were inserted in patients with malignancy and undergoing chemotherapy, with a high prevalence of neutropenia. The most common insertion site was the jugular vein.

Catheter-related bloodstream infection

One hundred and eleven catheter-related bloodstream infections were identified in short-term catheters, compared with 23 catheter-related bloodstream infections in long-term

Table II
Characteristics of short- and long-term catheters

CVC characteristics	Short-term catheters		Long-term catheters	
CVCs, <i>N</i>	2043		279	
Catheter-days, <i>N</i>	18,570		40,440	
Type of CVC, % (<i>N</i>)				
Standard	75.0	(1533)	—	
Swan Ganz	10.8	(222)	—	
Epicutaneous	6.1	(125)	—	
Hickman	—		27.6	(77)
Port-a-Cath	—		39.1	(109)
Permcath	—		33.3	(93)
Other	7.9	(163)	—	
CVC location, % (<i>N</i>)				
Subclavian vein	21.1	(431)	11.1	(31)
Jugular vein	49.3	(1008)	82.4	(230)
Femoral vein	19.3	(394)	2.9	(8)
Other	10.3	(210)	3.6	(10)
Parenteral nutrition, % (<i>N</i>)	18.6	(381)	1.8	(5)
Number of lumens, % (<i>N</i>)				
1	11.6	(237)	—	
2	12.6	(257)	—	
≥3	75.8	(1549)	—	
Hospital setting, % (<i>N</i>)				
ICU	31.3	(640)	—	
Operating theatre (anaesthesiologists)	40.2	(821)	—	
Recovery room (anaesthesiologists)	8.3	(169)	—	
Neonatal ICU	6.2	(127)	—	
Interventionist radiology	5.9	(120)	54.1	(151)
Operating theatre (surgeons)	—		23.7	(66)
Operating theatre (paediatric surgeons)	0.9	(18)	15.4	(43)
Other	7.2	(148)	6.8	(19)

CVC, central venous catheter; ICU, intensive care unit.

Table III

Annual burden of disease (incidence density per 1000 catheter-days) of catheter-related bloodstream infection

	Short-term catheters	Long-term catheters
Annual incidence density (N CRBSI/catheter-days)	5.98 (111/18,570)	0.57 (23/40,440)
First semester incidence density (N CRBSI/catheter-days)	6.40 (53/8287)	0.66 (16/24,206)
Second semester incidence density (N CRBSI/catheter-days)	5.64 (58/10,283)	0.43 (7/16,234)
Incidence rate ratio (95% CI)	0.81 (0.08–7.74)	0.67 (0.07–6.42)

CRBSI, catheter-related bloodstream infection; CI, confidence interval.

catheters. Incidence density rates for the entire year and the two semesters are shown in Table III. Higher rates of infection were found in catheters inserted in the femoral vein (8.7% vs other 3.9%; $P < 0.001$), catheters used for parenteral nutrition (8.4% vs 3.8%; $P < 0.001$), and catheters with more lumens (one lumen, 1.7%; two lumens, 2.4%; three lumens, 5.7%; $P < 0.001$). The micro-organisms identified in short-term catheters were: coagulase-negative staphylococci, 46.8%; *Pseudomonas aeruginosa*, 20.7%; *Candida* spp., 8.1%; *Enterobacteriaceae*, 13.5%; *Enterococcus* spp., 3.6%; *Staphylococcus aureus*, 3.6%; and other, 3.6%. Micro-organisms identified in long-term catheters were: coagulase-negative staphylococci, 61.1%; *Candida* spp., 4.8%; *Enterobacteriaceae*, 9.5%; *Enterococcus* spp., 4.8%; *Staphylococcus aureus*, 4.8%; and other, 14.3%. No cases of methicillin-resistant *Staphylococcus aureus* were identified, and 33% of *Enterobacteriaceae* were extended-spectrum beta-lactamase producers.

Compliance with recommendations during insertion and maintenance procedures

In total, 140 catheter insertion procedures in all hospital settings were observed (70 h of observation). The average time for insertion was 13 (standard deviation 7) min. Compliance with recommendations was as follows: hand hygiene, 86.8% (81.6% and 95.5% in first and second semesters, respectively); use of alcoholic chlorhexidine solution for skin disinfection, 35.5% (34.0% and 37.5%); use of mask, 93.4% (87% and 100.0%); use of gloves, 98.7% (100.0% and 98.1%); use of gown, 75.0% (64.2% and 100.0%); use of sterile cloth, 93.8% (91.4% and 94.3%); use of cap, 92.2% (88.6% and 100.0%); bandage application, 62.7% (50.0% and 93.8%); and use of aseptic technique, 89.5% (88.3% and 90.2%). All staff who participated in a given procedure complied with the recommendations in 78.9% of cases (68.7% and 93.9% in first and second semesters, respectively). Forty-five maintenance procedures were observed, and compliance rates were as follows: hand hygiene, 42.1%; use of gloves, 78.1%; and port disinfection with alcoholic chlorhexidine solution, 32.5%.

Discussion

To the authors' knowledge, this is the first study to obtain data on the annual burden of disease of catheter-related

bloodstream infections in a tertiary hospital, covering all hospital settings, and including short- and long-term catheters.

A low level of compliance with some recommendations was observed during insertion or maintenance of catheters in the study hospital, in agreement with other studies.²⁵ This suggests that in addition to the promotion of clear and updated clinical guidelines, there is a need for continuing staff education and periodic checks to assess gaps in practice and establish improvements. This study found significant deficiencies in hand hygiene and port disinfection during catheter maintenance, while these practices were performed with acceptable compliance during insertion procedures. Low use of alcoholic chlorhexidine solution was observed, as healthcare workers preferred to use povidone-iodine before catheter insertion, and aqueous chlorhexidine solution for catheter care. This corresponds with the progressive but slow availability of coloured alcoholic chlorhexidine solution in all hospital settings. Compliance with almost all parameters improved in the second semester, but the number of procedures observed was small. A one-year study may have been too short to expect a significant improvement in compliance. The deficiencies in safety measures observed during catheter insertion (performed by doctors) and maintenance (performed by nurses) were different. Therefore, there is a need for refresher courses for homogeneous groups, stressing the infection control practices according to each professional role. The courses should also be periodic and cyclic, because healthcare workers who attend more courses appear to be more likely to comply with recommendations.²⁷

The incidence of catheter-related bloodstream infection in the study hospital is higher compared with other hospitals with similar characteristics.^{6,15} According to the EPINE study,²⁸ bacteraemia has increased in Spanish hospitals in recent years, becoming the third leading cause of healthcare-associated infection. This study identified a high percentage of coagulase-negative staphylococci and a low percentage of Gram-negative bacteria, especially in long-term catheters. This pattern is related to the inclusion of all wards, because if the ICU is considered alone, coagulase-negative staphylococci were found in 39.2% of catheters, similar to other ICU-based studies.^{6,13} Catheter-related bloodstream infection declined in all hospital settings after six months of the programme. The decrease was not significant, possibly because the follow-up time was short, but it is hoped that this will become significant with maintenance of the programme. This intervention does not imply an obligation or sudden change in the routine of professionals, but rather a gradual process of self-management through the improvement of knowledge about recommendations and the importance of compliance, and more individualized recommendations according to each professional role.

There are limited studies on catheter-related bloodstream infection in long-term central venous catheters, and most were conducted on specific population groups, such as patients with cancer or receiving haemodialysis. There are still important unresolved issues, such as whether or not to remove the device when an infection is diagnosed, the validity of certain technologies and devices, and handling techniques to avoid contamination.²⁹ This study reported the total burden of disease of catheter-related bloodstream infection, device characteristics and patient characteristics. After starting the programme, the number of long-term catheter-related bloodstream infections decreased, although this was not significant.

The impact of catheter-related bloodstream infections in long-term catheters is greater than that in short-term catheters, so there is a need for further study to identify appropriate measures to avoid complications related to the use of long-term catheters.

The limitations identified are specific to this type of study. It is impossible to determine the degree of improvement that was attributable to the programme, rather than that due to the presence of a surveillance system itself. Compliance with recommendations may have been overestimated, because the healthcare workers may have improved their performance as they were being observed by a person outside their usual team (Hawthorne effect). In the study hospital, the presence of observers is not a novelty, as this method had been in use for four years prior to this surveillance. Direct external observation of catheter insertion needs the cooperation of the units to notify the observer before proceeding. This could generate selection bias, and led to a small sample size in the present study. However, it does permit the collection of very reliable data.

In conclusion, the control and prevention programme implemented at the study hospital has decreased the rate of catheter-related bloodstream infection, provided important information about the total burden of disease, and revealed possible ways to improve interventions in the future.

Conflict of interest statement

None declared.

Funding sources

The programme was supported by the Carlos III Health Institute, Ministry of Science and Innovation of Spain (Grant Number: PI080881). Additional support was provided by the Foundation for Research of the General University Hospital of Alicante, Spain (Grant Number: PC-06/2009).

References

1. Sánchez-Payá J, Bischofberger C, Lizan M, et al. Nosocomial infection surveillance and control: current situation in Spanish hospitals. *J Hosp Infect* 2009;72:50–56.
2. Rosenthal VD, Maki DG, Mehta A, Alvarez-Moreno C, Leblebicioglu H; International Nosocomial Infection Control Consortium Members. International Nosocomial Infection Control Consortium report, data summary for 2002–2007, issued January 2008. *Am J Infect Control* 2008;36:627–637.
3. Wenzel RP, Edmond MB. Team-based prevention of catheter-related infections. *N Engl J Med* 2006;355:2781–2783.
4. Suetens C, Morales I, Savey A, et al. European surveillance of ICU-acquired infections (HELICS-ICU): methods and main results. *J Hosp Infect* 2007;65(Suppl. 2):171–173.
5. Tacconelli E, Smith G, Hieke K, Lafuma A, Bastide P. Epidemiology, medical outcomes and costs of catheter-related bloodstream infections in intensive care units of four European countries: literature- and registry-based estimates. *J Hosp Infect* 2009;72:97–103.
6. Esteve F, Pujol M, Ariza J, et al. Impact of a prevention program for catheter-related bloodstream infection in the intensive care unit of a tertiary hospital. *Enferm Infecc Microbiol Clin* 2009;27:561–565.
7. O'Grady NP, Alexander M, Dellinger EP, Gerberding JL, Heard SO, Maki DG. Guidelines for the prevention of intravascular catheter-related infections. Centers for Disease Control and Prevention. *MMWR Recomm Rep* 2002;51:1–29.
8. Marshall J, Mermel LA, Classen D, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29(Suppl. 1):S22–S30.
9. Warren DK, Yokoe DS, Climo MW, et al. Preventing catheter-associated bloodstream infections: a survey of policies for insertion and care of central venous catheters from hospitals in the Prevention Epicenters Program. *Infect Control Hosp Epidemiol* 2006;27:8–13.
10. Warren DK, Zack JE, Mayfield JL, et al. The effect of an education program on the incidence of central venous catheter-associated bloodstream infection in a medical ICU. *Chest* 2004;126:1612–1618.
11. Guembe M, Bustinza A, Sánchez Luna M, et al.; GEIDI and ECCAUPE Study Groups. Guidelines for preventing catheter infection: assessment of knowledge and practice among paediatric and neonatal intensive care healthcare workers. *J Hosp Infect* 2012;81:123–127.
12. Aloul B, Adabag AS, Goussous TY, Weinert CR. Medical residents's self-reported adherence to guidelines during placement of central venous catheters. *Infect Control Hosp Epidemiol* 2008;9:86–88.
13. Conrick-Martin I, Foley M, Roche FM, et al. Catheter-related infection in Irish intensive care units diagnosed with HELICS criteria: a multi-centre surveillance study. *J Hosp Infect* 2013;83:238–243.
14. Eggimann P, Harbarth S, Constantin MN, et al. Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. *Lancet* 2000;355:1864–1868.
15. Yoo S, Ha M, Choi D, Pai H. Effectiveness of surveillance of central catheter-related bloodstream infection in an ICU in Korea. *Infect Control Hosp Epidemiol* 2001;22:433–436.
16. Coopersmith CM, Rebmann TL, Zack JE, et al. Effect of an education program on decreasing catheter-related bloodstream infections in the surgical intensive care unit. *Crit Care Med* 2002;30:59–64.
17. Galpern D, Guerrero A, Tu A, Fahoum B, Wise L. Effectiveness of a central line bundle campaign on line-associated infections in the intensive care unit. *Surgery* 2008;144:492–495, discussion 495.
18. Costello JM, Morrow DF, Graham DA, Potter-Bynoe G, Sandora TJ, Laussen PC. Systematic intervention to reduce central line-associated bloodstream infection rates in a pediatric cardiac intensive care unit. *Pediatrics* 2008;121:915–923.
19. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med* 2006;355:2725–2732.
20. Pronovost PJ, Goeschel CA, Colantuoni E, et al. Sustaining reductions in catheter related bloodstream infections in Michigan intensive care units: observational study. *BMJ* 2010;340:c309.
21. Berenholtz SM, Pronovost PJ, Lipsett PA, et al. Eliminating catheter-related bloodstream infections in the intensive care unit. *Crit Care Med* 2004;32:2014–2020.
22. Zingg W, Sax H, Inan C, et al. Hospital-wide surveillance of catheter-related bloodstream infection: from the expected to the unexpected. *J Hosp Infect* 2009;73:41–46.
23. Trick WE, Miranda J, Evans AT, Charles-Damte M, Reilly BM, Clarke P. Prospective cohort study of central venous catheters among internal medicine ward patients. *Am J Infect Control* 2006;34:636–641.
24. Trick WE, Vernon MO, Welbel SF, Wisniewski MF, Jernigan JA, Weinstein RA. Unnecessary use of central venous catheters: the need to look outside the intensive care unit. *Infect Control Hosp Epidemiol* 2004;25:266–268.
25. Shapey IM, Foster MA, Whitehouse T, Jumaa P, Bion JF. Central venous catheter-related bloodstream infections: improving post-insertion catheter care. *J Hosp Infect* 2009;71:117–122.
26. Kallen AJ, Patel PR, O'Grady NP. Preventing catheter-related bloodstream infections outside the intensive care unit: expanding prevention to new settings. *Clin Infect Dis* 2010;51:335–341.

27. Sánchez-Payá J, Galicia-García MD, Gracia-Rodríguez RM, et al. Compliance with hand hygiene guidelines and determinants of compliance. *Enferm Infecc Microbiol Clin* 2007;25:369–375.
28. Vaqué J; Grupo de Trabajo EPINE. Resultados del 'Estudio de Prevalencia de las Infecciones Nosocomiales en España (EPINE-EPPS 2012)', en el contexto del: European Prevalence Survey of Healthcare-Associated Infections and Antimicrobial Use (EPPS). Madrid: Sociedad Española de Medicina Preventiva, Salud Pública e Higiene; 2013.
29. Stefanidis CJ. Prevention of catheter-related bacteremia in children on hemodialysis: time for action. *Pediatr Nephrol* 2009;24:2087–2095.