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Formation of Nursing Staff in Intensive Care Units: Evaluation of Adherence to Recommendations and Variability in Management of Central Venous Catheters

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Abstract: The use of devices such as catheters is crucial in the formation of nursing professionals. Venous catheters are extensively used in the healthcare system, primarily in ICUs. Although its effectiveness has been proved, its use implies complications such as bacteremia associated to its insertion and maintenance, with associated morbidity and mortality rates. The objective of this investigation was to evaluate the effect of variability in the management of Central Venous Catheters (CVCs) by nursing professionals in intensive care units, as well as their adherence to CDC recommendations and the importance of nursing staff in this regard. Using the National Patient Safety Goals, hospital accrediting agencies require hospitals to keep their healthcare professionals, including students, properly educated with regard to the competencies and skills associated with their profession before beginning clinical practice. This way, they are better prepared to practice their profession and will be able to reduce the risk of complications in patients. It is up to educators to keep their students up to date with regard to the development of practices based on new scientific evidence, particularly concerning the use of devices, in this case CVCs, so that these professionals are better prepared for the work field upon completion of their degree..

Key-Words: Nursing Education, Nursing Competencies, Adherence, Bacteremia, Central Venous Catheter, CDC, Intensive Care, Clinical Practice.

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1. Introduction

Venous catheters are increasingly used in hospitals, in ambulatory procedures and above all in intensive care units. In the United States, approximately 30 million of these are used yearly. Of this amount, 3 million are of the central venous catheter type (CVCs) (Kusek, Soule, Kupka, Williams & Koss, 2013). Although the effectiveness of catheters has been proven, its use implies a great amount of complications, among them bacteremia associated to insertion and maintenance of the instrument, causing a significant amount of morbidity and mortality in patients (Philippart, Max, Couzigou & Misset, 2013; O'Grady, N.P., et al., 2011).

Nosocomial infection (caused by the invasion of bacteria in the blood) related to the use of central catheters is within the ten most frequent injuries associated to incidents in health care (Organización de la Salud, 2010). Blood infections are reported annually in one of every twenty hospitalizations in the United States and Puerto Rico associated to central lines; they are a cause of hospital deaths, with a mortality rate of 12% to 25%, and critical patients are among those with the greatest incidence of this problem (Malpie et al, 2011).

The rise of new multiresistant bacteria worsens this situation (Ruiz, Montelli, De Fátima, Silvaa, De Batista, Matuura, Moreira, & Paula, 2013). Despite these risks and complications, the use of catheters appears to be here to stay (Philippart, Max, Couzigou, & Misset, 2013).

This has led to the creation of recommendations, guidelines and preventive and epidemiological strategies aimed mainly towards personnel working with central line patients (Almirante & Pahissa, 2013). Nurses are vital components in these scenarios, so they must not only incorporate this new knowledge in clinical practice, but also participate in its procurement. It is the responsibility of all nursing professionals to attend to professional development and growth activities to guarantee secure patient care. The information must be updated to reflect updated and evidence-based practices (Ingwerson, 2016). However, the mere availability of evidence for prevention of complications associated to CVCs does not guarantee its systematic application in patients, and analyses and studies concerning the extent to which patients are benefitting from the existing knowledge on this subject is crucial. Nursing professionals are key to improve access to attention and quality through the formative milestones evidenced in clinic practice (Ingwerson J., 2016).

The objectives of this study were to describe the frequency of infections related to central catheters in intensive care patients, to analyze patients' factors associated to the appearance of infections related to central catheters and its consequences on mortality, length of stay and readmission; to explore the adherence and knowledge of professional nurses in Intensive Care Units as relates to CDC recommendations for infection prevention and management of CVCs; and to identify and characterize the actions and strategies used in dif-

ferent hospitals to implement recommendations on the management of critical patients with central line catheters by nursing staff in ICUs.

2. Methodology

2.1 Design

An analytic retrospective observational study was carried out for analysis of the first two objectives, and a transversal analytic study for the last two. Two units of analysis were used for the study: nursing professionals working in the intensive care unit of the participating hospitals and clinical files of patients who had a CVC during the years 2009 and 2012.

2.2 Sample of patients' clinical files

The sample of patients was obtained through files of patients older than 21 who had central catheters in 2009 and 2012 of hospital 1 and hospital 2. No sampling was carried out; rather, the whole qualifying population during these periods was selected. However, we estimated the necessary sample assuming an incidence of 1.65 infections for every 1,000 days of central venous lines in ICU patients (CDC, vital signs, 2011) with an alpha value of 0.05 and a 0.2% rate of precision. For a total population of 164 patients a year with CVCs in both participating hospitals, 138 patients were necessary. Once the necessary sample was established, all subjects who had CVCs during the studied periods (2009 and 2012) admitted to the intensive care unit were included. On the other hand, for objectives concerning nursing professionals, no sampling was carried out; rather, the complete nursing population working in the ICUs of the participating hospitals were voluntarily surveyed.

In the case of patients, up to 164 clinical files of subjects with CVCs admitted to the ICUs of the two hospitals during the studied period (2009 and 2012) were included, whether they were inserted in the same unit or in another hospital, of both genders and older than 21, with a minimum stay of 12 hours in the ICU. Patients admitted to the ICU for less than 12 hours and those younger than 21 were excluded.

In the case of nurses, all nursing personnel older than 21 years working in the intensive care units of both participating hospitals who willingly decided to participate were surveyed. Nursing professionals who worked for less than three months during the studied period were excluded (short-term substitutions and those who had some permanent link to the unit, but were absent from it for any reason for more than 3 months, such as permits, licenses and sick leave), as were nursing professionals who did not work in ICUs.

2.3 Instruments

Two questionnaires were used for data collection: the first one was designed by Labeau (2008), Vereecke, Vandijck, Claes & Blot (2008), who

authorized its use, and which was translated from English to Spanish by Colón (2016). The questionnaire focused on two areas: sociodemographic profile and knowledge of catheter maintenance. The instrument is composed mainly of 10 items (questions) for a total score of 10: 1 point was assigned for each correct answer. From this information, and for evaluation and classification purposes, the global knowledge score was calculated (PGC, for its Spanish acronym). The second questionnaire used was the CDC (2011), which explores nursing adherence to CVC maintenance recommendations.

2.4 Ethical and legal aspects

In order to carry out an ethical and correct process during the study, the researcher obtained IRB and HIPAA certifications associated to federal confidentiality law and the protection of human rights. The protection of human subjects was guaranteed, the principles of confidentiality were observed, as well as the protection of identity; the questionnaires and CD containing the information of patients' files in Excel format were stored in the principal address of the principal investigator. After 5 years the questionnaires will be destroyed with a paper shredder and the CD with a compact disk shredder. Study approval was obtained from the Institutional Review Board (IRB) of the Metropolitan University. Authorization was obtained from both hospitals where the study was carried out for administration of the questionnaire to health care professionals working in the intensive care unit and to collect information from the files of patients hospitalized in 2009 and 2012.

2.5 Data collection

After obtaining IRB approval, patient lists were obtained from the Computer Center Departments (in both hospitals where authorization was received to carry out this study), without identifiers, corresponding to those admitted to the ICUs in 2009 and 2012 with central venous catheters. For the purposes of the study, clinical patient files were identified by means of an alphanumeric code.

The information of patients' clinical files was obtained from their clinical history, nurses' notes, microbiological results and medical progress notes. The information obtained was transferred to an Excel sheet including demographic variables, intrinsic and extrinsic risk factors and information of diagnosed infections. The information was then exported for analysis in SPSS 21.

2.6 Analysis

A descriptive analysis was carried out using central tendency and dispersion measures as well as the Kolmogorov-Smirnov goodness of fit test. Bivariate analysis was carried out using Student's t-test and chi-square according to the characteristics of the analyzed variables, when they were normally distributed. In the opposite case, non-parametric tests were used such as

the Wilcoxon signed rank test and the Mann-Whitney U test. Likewise, ANOVA was used for the quantitative and qualitative analysis of variables in pertinent cases, with robust measures of central tendency in cases of non-homoscedasticity (as measured by Levene's test) using the Welch and Brown-Forsythe tests. Confidence intervals were calculated at 95%.

3.Results

The total patient sample was composed of 164 subjects with a median age of 72.78 (SD: 15.01). 43.30% of these were men and 55.5% women. The sample was distributed, with 117 subjects in the first hospital (71.30%) and 47 in the second one (28.70%). Organized by period, 39.00% (n = 64) of patients belonged to the first wave of samples (2009) and 61.00% (n = 100) to the second (2012). Organized by type of patient, the most frequent type consisted of those who had cardiovascular conditions (n = 43, 26.20%), followed by respiratory (n = 38, 23.20%) and infectious diseases (n = 19, 11.60%). These three types of patients made up more than half of the sample (61%). 54 patients died in intensive care (32.9%), and 53 within 30 days of hospitalization. 17.7% (n = 29) of the patients were readmitted to the hospital.

Of 164 evaluated patients, 147 (90%) had urinary catheters, 78 (48%) received mechanical ventilation care, 70 (43%) nasogastric tubes and 46 (28%) received parenteral nutrition. CVC insertion areas for 140 patients (85.9%) were in the jugular vein (90, 54.9%) and the subclavian vein (n = 50, 30.5%).

Concerning bandage changes to the CVC area, 40 of the patients (24.4%) underwent one change, followed by 21 patients (12.8%) who had two changes. 20 (12.2%) patients with CVCs underwent three changes. 81 patients, representing 70.7% of the sample, received between one and three changes. However, a greater amount of changes was carried out for the rest of the patients, to a lesser degree. No information on this variable was available for 35 (21.3%) patients.

Finally, patients with urinary catheters spent approximately 16 days with the catheter, followed by central venous catheter patients, who spent approximately 14 days. Patients with the other appliances: mechanical ventilator, nasogastric tubes and parenteral nutrition, had the catheters for 6, 5 and 3 days, respectively.

73.8% of evaluated patients acquired one of the following infections during their stay in the hospital: 53 patients (32.3%) acquired pneumonia, 45 (27.4%) acquired urinary tract infections, 15 (9.1%) CLABSI and 8 (5%) sepsis. Of these patients, 10% (n = 17) presented two acquired infections, among them sepsis, UTI or CLABSI.

Appliance	**Hospital 1**		**Hospital 2**		**Total**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Urinary Catheter	106 (90,6%)	11 (9,4%)	41 (87,2)	6 (12,8%)	147 (89,6%)	17 (10,4%)
Mechanical Ventilator	63 (53,8%)	54 (46,2%)	15 (31,9%)	32 (68,1%)	78 (47,6%)	86 (52,4%)
Parenteral Nutrition	35 (29,9%)	82 (70,1%)	11 (23,4%)	36 (76,6%)	46 (28,0%)	118 (72,0%)
Nasogastric Tube	54 (46,2%)	63 (53,8%)	16 (34,0%)	31 (66,0%)	70 (42,7%)	94 (57,3%)
CVC Insertion Area	**Hospital 1**	**Hospital 2**	**Total**			
	F	**%**	**F**	**%**	**F**	**%**
Subclavian Vein	26	22,4	24	51,1	50	30,7
Jugular Vein	73	62,9	17	36,2	90	55,2
PIC Line	8	6,9	2	4,3	10	6,1
Femoral Vein	9	7,8	4	8,5	13	8,0
Total	116	100,0	47	100,0	164	100,0

Table 1. Distribution of appliance characteristics and invasive techniques in patients by hospital.

Patient deaths in the ICUs were high for both hospitals, with a slightly higher rate in hospital 1. The difference in death distribution of patients in intensive care by hospital was statistically significant ($p = 0.046$). Deaths during the 30-day stay of patients were similar for both hospitals, as both showed high death rates during the admittance period. Distribution of patients' death by hospital was not statistically significant ($p = 0.066$).

Significant differences were observed in terms of days spent with a mechanical ventilator ($p = .006$) and parenteral nutrition ($p = .004$) between hospitals. For the rest of the studied variables, no significant differences between hospitals were identified. Regarding the distribution of infections acquired during patients' admittance in intensive care by hospital, no significant difference was observed ($p = .079$).

Finally, CLABSI analysis was carried out using standardized indicators for comparison with the obtained sample using CLABSI rates in Puerto Rico obtained in the INNIC study. The adjusted CLABSI rate for 1,000 days of CVC in hospital 1 was similar to that seen in the rest of the country. On the other hand, in hospital 2, this standardized rate showed an increased incidence of CLABSI in comparison to the rest of the country.

Days with CVC	CLABSI	CLABSI rate*	SRI**	
Hospital 1	1617	11	6,8	1
Hospital2	651	6	9,2	1,36
Total	**2268**	**17**	**7,5**	1,1

*CLABSI / 1.000 days CVC

Table 2. Analysis of CLABSI according to international standardized indicators.

The characteristics of evaluated patients were studied through bivariate analysis to detect possible correlations between the studied factors and infections associated to CVCs and other appliances by year (2009 and 2012). No significant differences were observed as regards mechanical ventilation (p = .749), urinary catheter (p = 1.0), parenteral nutrition (p = 0.725), catheter insertion area (p = .05) or mortality rate (p = 0.610).

The distribution of patients with nasogastric tubes differed. In hospital 1, 46.2% of patients had the device, while in hospital 2, 34.0% did not.

The distribution of infections acquired during the hospital stay of patients in the intensive care units was studied by period, and a significant reduction was seen in 2012 except for sepsis, which increased (p = .015).

For the 2012 period, the proportion of patients with CLABSI was higher in both hospitals, at a rate of 10.3% in hospital 1 and 9.2% in hospital 2, although this difference was not significant (p = 1.0), when compared to the rate in 2009, 7.7% in hospital 1 and 7.7% in hospital 2 (p = .417). However, globally, the proportions were similar; approximately 10% (n = 17) of patients had CLABSI during both periods.

No significant differences were observed for mortality rate in CLABSI patients in intensive care during either period (2009, p = .406) (2012, p = .720). No significant differences were observed in mortality rates during the 30-day period in either hospital, either in 2009 (p = .406) or 2012 (p = .719).

Significant differences were observed regarding CLABSI patients and readmission per period; namely, no significant difference was observed in 2009 (p = .142), but a difference was seen in 2012 (p = .009).

Significant differences were observed regarding length of hospital stay in 2009 (p = .018) and in 2012 (p = .004), days with urinary catheters (p = .007), days with CVCs (p = .017) and days with nasogastric tubes (p = .028).

The distribution of patients with CLABSI by CVC insertion area and type of appliance was evaluated. According to the chi-square test, no significant differences were seen for patients with mechanical ventilators (p = .798), urinary catheters (p = 0.390), parenteral nutrition (p = .086) and nasogastric tubes (p = .070). CLABSI risk estimates confirmed no association with parenteral nutrition (.918; 7,081), mechanical ventilators (.465; 3,478), nasogastric tubes (.918, 7,798) and urinary catheters (1.26; 1,920).

Regarding the distribution of CVC insertion area by CLABSI infection, the greatest proportion of CLABSI infections was seen in cases of jugular

vein insertion (47.1%) followed by subclavian vein insertion (35.3%), although this difference was not significant (p = 0.872).

To indicate the fluctuation of patient factors with regard to CLABSI infection and its consequences on mortality and hospital stay and readmissions, logistic regression was used as a test of multivariate probabilistic prediction.

In the first model, the presence of urinary catheters, nasogastric tube and days with central venous catheters and parenteral nutrition were used as independent variables. Results indicate that the presence of CLABSI was less probable in patients with urinary catheters as well as those who spent more days with CVCs, parenteral nutrition and nasogastric tubes.

Variables	B	Standard Error	Wald	DOF	*P* value	OR	95% C.I.	
							Lower	Upper
Urinary catheter	-2.112	.883	5.725	1	.017	.121	.021	,682
Days with CVC	.098	.031	10.228	1	.001	1.103	1.039	1,172
Days with parenteral nutrition	.089	.037	5.798	1	.016	1.094	1.017	1,176
Nasogastric tuve	1.479	.660	5.022	1	.025	4.389	1.204	16,002
Constant value	-3.285	.878	14.004	1	.000	.037		

Table 3. Variables in the equation: first model.

Variables	OR	95% C.I.		*P* Value
		Lower	Upper	
Urinary catheter	.065	.010	.428	.005
Days with CVC	1.132	1.054	1.216	.001
Days with parenteral nutrition	1.088	.996	1.189	.063
Nasogastric tube	5.644	1.325	24.029	.019
Readmission	12.462	2.883	53.869	.001
Constant value	.017			.000

Table 4. Logistic regression model.

A third model was constructed adding hospital and time period as categorical variables to the second model, with no significant differences observed.

Variables	OR	95% C.I.		*P* value
		Lower	Upper	
Urinary catheter	.058	.008	.416	.005
Days with CVC	1.139	1.057	1.228	.001

Days with parenteral nutrition	1.093	.996	1.200	.060
Nasogastric tuve	6.758	1.483	30.803	.014
Readmission	12.702	2.859	56.440	.001
Hospital	.494	.124	1.966	.317
Period	.554	.137	2.229	.405
Constant value	.030			.002

Table 5.

An additional regression model was constructed substituting the presence of urinary catheters as a predictor variable for the presence of infection related to urinary catheters, but UTI was not found to be a risk factor for CLABSI. Previously, chi-square was used to associate the presence of urinary catheters to UTI frequency with no significant correlation found.

Variables	B	Standard Error	P Value	OR	95% C.I.	
					Lower	Upper
Days with CVC	.108	.028	.000	1.114	1.053	1.177
Nasogastric tube	1.124	.635	.077	3.077	.887	10.672
Readmission	2.247	.669	.001	9.456	2.548	35.091
Urinary Catheter	-1.865	1.060	.078	.155	.019	1.236
Constant value	-5.008	.899	.000	.007		

Table 6.

With regard to the barriers and knowledge of nurses on CVC management and adherence to guidelines of evidence-based care, the greatest proportion of correct responses (table 5, bold) were seen for items 1 (72%), 5 (70%), 6 (72%) and 9 (74%) related to the direct function of nurses in their work areas and central venous catheter changes. The number was below 70% for items 2, 3, 4, 7, 8 and 10, which represent most questions.

Questionnaire item	**Frequency**	**Percentage**
1. Routinely replace CVCs		
Yes, every seven days	9	18.0
Yes, every three weeks	1	2.0
No, only when indicated	36	72.0
Don't know	4	8.0
Total	50	100.0
2.Use a guiding wire to replace CVCs		
Yes, every seven days	2	4.0
Yes, every three weeks	2	4.0
No, only when indicated	32	64.0

Don't know	13	26.0
Yes, every seven days	49	98.0
Lost data	1	2.0
3.Routinely replace pressure transductors and tubes		
Yes, every four days	14	28.0
Yes, every eight days	1	2.0
No, only when instructed	26	52.0
Don't know	8	16.0
Total	49	98.0
Lost data	1	2.0
4. It is necessary to use antiseptic catheters		
Yes, in patients whose CVCs…	31	62.0
No, because the use of these catheters…	11	22.0
Don't know	8	8.0
Total	50	100.0
5. Change dressing in the catheter insertion area		
Daily	2	4.0
Every three days	12	24.0
When indicated (dirty, loose), at least every seven days	35	**70.0**
Don't know	1	2.0
Total	50	100.0
6. Cover the catheter insertion site with:		
Polyurethane dressing	36	72.0
Gauze dressing	1	2.0
Both are advisable…	12	24.0
Don't know	1	2.0
Total	50	100.0
7. Disinfect the catheter infection site with:		
2% aqueous chlorhexidine	14	28.0
0.5% chlorhexidine	18	36.0
10% povidone iodine	12	24.0
Don't know	5	10.0
Total	49	98.0
Lost data	1	2.0
8. Apply an antibiotic ointment when inserting a CVC		

Yes, because it reduces the risk of infection	19	38.0
No, because it causes resistance to antibiotics	11	22.0
No, because it does not reduce the risk of infection	12	24.0
Don't know	8	16.0
Total	50	100.0
9. When lipid emulsion… substitute adm…		
Within 24 hours	37	74.0
Every 72 hours	3	6.0
Every 96 hours	1	2.0
Don't know	8	16.0
Total	49	98.0
Lost data	1	2.0
10. When lipid emulsion doesn't… substitute adm…		
Every 24 hours	29	58.0
Cada 48 hours	9	18.0
Cada 96 hours	2	4.0
Don't know	8	16.0
Total	49	98.0
Lost data	1	2.0

Table 7.

Significant differences were seen in terms of nurses' knowledge by hospital of origin in item 6 (p = .049), which measures type of dressing required to cover the catheter insertion site, and itm 8 (p = .018), which measures wether applying an antibiotic ointment in the insertion site reduces the risk of catheter-related infections.

The variable of time spent by nurses working in the ICU, when correlated with the global knowledge score concerning evidence-based guidelines for the prevention of CVC-related infections, showed a Pearson correlation coefficient of 0.160, a positive and very weak correlation.

The variable of nurses' education on infection prevention (HAI), when correlated with the global knowledge score concerning evidence-based guidelines for the prevention of CVC-related infections, showed a Pearson correlation of 0.269, a positive and weak correlation. The greatest proportion of adherence in the clinical domain was 26%, in the installation domain 10%, and in the strategy domain 8%. However, the significance test indicated no significant difference between nursing personnel adherence by domain and hospital: Clinical (p = .399), installations (p = .261) and strategy (p = .506).

As concerns domains of adherence when correlated to the academic level of nursing personnel and post-graduate education of nursing personnel

working in intensive care, no significant differences were found between domains of adherence and nurses' education level. Clinical adherence was compared with years of experience of ICU nursing personnel, showing a significant, negative and weak correlation.

The variables of years of experience of nursing personnel in the ICU, when correlated to the facilities domain score, showed a positive, weak Spearman's rho correlation ($\rho = .005$). No significant differences were seen with regard to the global knowledge score across nurses by hospital of origin.

Significant differences were found with regard to adherence in the facility domain between professionals with 1 to 5 years of experience as compared to those with 6 to 10 years of experience, as well as between the latter group and professionals with 10 years of experience or more.

Dependent variable	(I) Years of experience as a nurse	(J) Years of experience as a nurse	Difference in averages (I-J)	*P* value	95% CI	
					lower	upper
Clinical						
Games-Howell	1 to 5	6 to 10	.50000	.588	-.7620	1.7620
		10+	.25000	.829	-.8128	1.3128
	6 to 10	1 to 5	-.50000	.588	-1.7620	.7620
		10+	-.25000	.791	-1.2606	.7606
	10+	1 to 5	-.25000	.829	-1.3128	.8128
		6 to 10	.25000	.791	-.7606	1.2606
Installations						
Games-Howell	1 to 5	6 to 10	.72222	.028	.0728	1.3717
		10+	.43056	.270	-.2490	1.1101
	6 to 10	1 to 5	-.72222	.028	-1.3717	-.0728
		10+	-.29167	.014	-.5290	-.0543
	10+	1 to 5	-.43056	.270	-1.1101	.2490
		6 to 10	.29167	.014	.0543	.5290
Strategy						
Games-Howell	1 to 5	6 to 10	.51389	.404	-.4722	1.4999
		10+	-.27778	.758	-1.2288	.6732
	6 to 10	1 to 5	-.51389	.404	-1.4999	.4722
		10+	-.79167	.106	-	.1400

					1.7234
10+	1 to 5	.27778	.758	-.6732	1.2288
	6 to 10	.79167	.106	-.1400	1.7234

Table 8. Multiple comparisons.

As regards the correlation between adherence area and nurses' global knowledge score, as presented in the following table, no significant correlation was found.

Correlations			
		Global Knowledge Score	
		Correlation coefficient	*P* value
Spearman's Rho	Clinical	.033	.817
	Installations	.003	.985
	Strategy	.133	.357

Table 9.

4. Discussion

The objective of this study was to evaluate the effect of variability in the management of CVCs by intensive care nursing professional as well as their adherence to recommendations in their professional formation.

The total sample of patients consisted of 164 subjects from two hospitals in the Metropolitan area of San Juan, Puerto Rico. The average age of the subjects was 73 years; 55% were men and 43% women. According to the 2014 report of chronic diseases in Puerto Rico for the years 2000 and 2010, the structural population of Puerto Rico is older; the population with at least 65 years increased by 46% (11.2% to 16.4%). This population was reflected in our study.

The most frequent patients were those with cardiovascular conditions, as according to the Chronic Disease Action Report for Puerto Rico for 2010 and 2020, cardiovascular conditions are the first causes of death in PR, and the data was similar to that observed in the United States.

33.9% of deaths occurred in ICUs, and 32.3% of deaths occurred within the first 30 days of general hospitalization. 17.7% of patients were readmitted to the hospital, and according to the information found, these readmissions were associated to CLABSI. The average days of hospitalization in intensive care of the 164 evaluated patients was 22.1 in hospital 1 and 12.7 in hospital 2. Hospital-acquired infections (HAIs) caused by the invasion of bacteria in the bloodstream and related to the use of central catheters (CLABSI) is within the ten most frequent injuries related to healthcare incidents, according to a 2010 report by the World Health Organization. This number implies a serious

and worrying risk, as it involves the deaths of patients. Annually, one of every 20 hospitalizations in the United States and Puerto Rico report a catheter-related blood infection, which can cause hospital deaths with a mortality rate of 12% to 25%, critical patients being among those with the highest incidence of this problem (Malpie et al, 2011).

Of the 164 evaluated patients, 90% had urinary catheters, 48% received mechanical ventilation care, 43% had nasogastric tubes, and 28% had parenteral nutrition. Due to the complexity of patients in critical care areas, most of them require the previously mentioned appliances. All patients had more than two devices, and literature indicates that this increases the risk of acquired infections and complications (Malpie et al, 2011).

Of the 99.4% of patients with CVC evaluated, 54.9% of were cannulated in the jugular vein. With regard to insertion area, evidence points to a lower infection rate for subclavian vein catheters (4 for every 1,000 catheters per day) when compared to internal jugular catheters (8.6 for every 1,000 catheters per day) as well as for femoral catheters (15.3 for every 1,000 catheters per day) (Kelbourne et al, 2009). According to these authors, the subclavian vein is more accessible than the internal jugular vein, especially for trauma patients and those with cervical collars. The femoral artery can be cannulated without interruption of the airway, but there is a higher infection rate. The femoral catheter must be changed frequently to a subclavian or internal jugular catheter (Kelbourne et al, 2009). The internal jugular vein and type of hemodialysis are factors associated with deep vein thrombosis (Malinouski et al, 2013). According to the author, this information can be used to determine the ideal insertion site and type of catheter. Various authors point out that catheters inserted in the jugular or femoral vein are colonized more quickly than those inserted in the subclavian vein (Seisdedos, 2012). For this reason, doctors should choose the best CVC cannulation site to reduce infection risk.

With regard to bandage changes by nurses, 21.3% did not carry out or did not document the procedure, which includes cleaning of the CVC cannulated area every seven (7) days as per CDC Central Venous Catheter Patient Management guidelines (2011). According to the study, nurses play principal roles in these scenarios, for which reason they must not only incorporate this new scientific evidence in clinical practice, but also participate in its procurement and document it in patients' files.

Five scientific evidence measures used by recommendation of the CDC have significantly reduced bacteremia associated to central catheters: maximum sterile barriers, handwashing, cleaning insertion site with chlorhexidine, avoiding the use of the femoral vein for insertion, as well as the quick removal of unnecessary catheters in critical patients (Valls & Garcia, 2010). Other recommendations include: indications of the catheter, choice of appliance, choice of pathway, hand hygiene, use of maximum barrier in CVC man-

agement and documentation of information in patients' files, such as date of insertion, type of catheter, pathway used, reason for insertion, date of removal and cause (CDC, 2011). In this variable associated to compliance with bandage changes, documentation was severely lacking, as there was insufficient evidence in the files. Wemay can infer that, if there is no written evidence, maintenance procedures for patients with CVC were not carried out.

Bloodstream infection rates related to central catheters, according to the International Nosocomial Infection Control Consortium (INICC, 2013), occur at a rate 2 for every 1,000 days spent with central catheters in developed countries, and 7 CLABSI for every 1,000 days with CVC in developing countries, three times higher than in the United States. Puerto Rico is considered a developed country, for which reason 2 infections for every 1,000 days was used as the standard value. CLABSI rates in hospital 1 were similar to that of other hospitals in Puerto Rico. However, in hospital 2, a 36% higher CLABSI rate was seen when compared to the standard value.

73.8% of patients (n = 121) studied acquired one of the following infections during their stay in intensive care in both hospitals: pneumonia, UTI, CLABSI and sepsis. According to investigators such as Kusek, Soule, Kupka, Williams & Koss (2013), these conditions are the most commonly acquired infections due to the use of the devices. For this reason, patients are more susceptible to complications. We found that 10% of patients (n = 17) acquired more than one infection during their time in intensive care.

Differences were seen in terms of CVC insertion site. In hospital 1, the subclavian vein was the most common insertion site, and the jugular vein in hospital 2. Literature points out that catheters inserted in the jugular or femoral vein are colonized more quickly than those in the subclavian vein, so we can infer that hospital 2 does not choose the best CVC cannulation site for patients, therefore the evidence points towards a higher risk for these patients.

A reduction in amount of substitutions was seen for hospital 1. This group of patients has a lower risk of bacteremia than those who undergo substitution, according to literature.

The average of days for patients with parenteral nutrition was higher for patients of hospital 1 than those of hospital 2. According to the World Health Organization, CVCs are used to provide parenteral nutrition to patients, and one of the benefits of TPN consists of administering nutrients to the organism with the purpose of maintaining the patient in a good nutritional state. However, patients who receive nutrients by the parenteral pathway and spend more than 12 to 15 days with TPN are more exposed to risks.

Finally, significant differences were seen in the distribution of mortality during the time spent in intensive care for patients between the two hospitals. Hospital 1 showed more deaths than hospital 2. Literature indicates that nosocomial infections are within the ten most frequent lesions associated to healthcare incidents (World Health Organization, 2010). Hospital 1 had a

greater number of patients with mechanical ventilators, and this device makes patients more vulnerable to complications. This number implies a serious risk as it involves the possible deaths of patients associated to mechanical ventilator complications.

2009 was selected for the study as the CDC revised the Practice Guidelines for Central Venous Access in early 2009 for the first time (CDC Guidelines, 2009), and 2012 was selected as it was one year after the second revision in 2011 (O'Grady, Alexander, Burns, Dellinger, Garland, Heard, & Saint, 2011). In this last revision, the guideline recommendations became more rigorous. Among other things, changes were made regarding insertion site care as well as the use of chlorhexidine for cleaning, the use of transparent bandages, among others. The use of the betadine ointment in the healing process was discontinued. Checklists were implemented to facilitate the process. This revision also addressed the frequency of cleaning in the insertion area; instead of every 48 hours of site care, the recommendation of the CDC is seven days. For this purpose, we aimed to evaluate nurses' adherence to the recommendations and variability in the management of patients with central venous catheters in intensive care personnel. This is why these years were selected, as they were fundamentally important in the development and management of patients with CVCs in hospitals in Puerto Rico, particularly those in intensive care.

Significant differences were seen in the distribution of amount of CVC substitutions and dressing changes between each period. In 2012, a reduction in the amount of CVC substitutions was seen. This is a positive finding in our study, as according to CDC Guidelines, it is not a matter of routinely changing the central venous catheter, but rather of daily evaluating the clinical need for maintaining or discontinuing the CVC, thus reducing the risk of catheter contamination. We can infer that this reduction was due to the education surgeons obtain regarding the importance of substituting CVCs as little as possible, and the education offered to nursing professionals on changing bandages as per CDC recommendations.

There were other factors associated to risk of CLABSI infection in 2012: readmission, length of stay at ICUs, days with a mechanical ventilator, days with a urinary catheter, days with CVC and days with nasogastric tubes. The factor associated to risk of CLABSI infection in 2009 was the amount of days spent in intensive care during the 30-day period.

Ceballos-Acevedo, Velásquez-Restrepo y Jaén-Posada (2014) carried out a study on hospital stay where the average of days spent per patient was used as an indicator of efficiency, as according to scientific evidence, it implies the best usage of hospital beds and agility of services offered in the hospitals. Jiménez, cited by Ceballos, also points out in his study that a prolonged stay can be considered an indicator of lack of efficiency in patient flow and can have effects on the risk of adverse events and mortality. The conclusions

of the study by Ceballos-Acevedo, Velázquez-Restrepo and Jaén-Posada (2014) concerning the causes of prolonged stays were the following: delays in carrying out surgical procedures, early diagnosis, need for more complex attention, socio-familial situations and patients' age.

Data analysis showed that those patients with urinary catheters had a lower risk of CLABSI. This information was contradictory insofar as the CDC points out that it is the most common healthcare-related infection, showing a high morbidity and mortality rate in patients, as well as the second most common cause of secondary bloodstream infections. In fact, in our study's sample, 29.9% (n = 49) of subjects had a UTI, although no association was found between the presence of urinary catheters and UTIs despite the clear relationship existing between both factors (Galiczewski, 2016). The only plausible explanation for this finding is attributable to a lack of a sufficient sample to attain the statistic power necessary to establish this association.

Álvarez-Lerma, Olaechea, Inssausti y Cerda (2013) carried out a study on urinary infections related to urethral catheters for patients in critical care units in Spain. They prospectively included all patients with urinary catheters during more than 24 hours between 2005 and 2010, as well as the amount of days the patients spent with the catheter. The objective was to describe the evolution of national rates of urinary infections related to urethral catheters, as well as etiology and multiple resistance markers. The results of this study point towards a reduction of days with urethral catheters but an increase of resistant strains.

According to a report by the Department of Health of Puerto Rico, CAUTI levels are at 48%, close to the national rate of 50%, acceptable in terms of significant infection rates (SIR).

Although our study did not evaluate antibiotic-resistant infections, multiresistant infections related to CAUTI in Puerto Rico, as per 2015 information, showed a 34% resistance to antibiotics, a reduction when compared to 2010 (Díaz, 2016), in conflict with the study by Álvarez-Lerma, Olaechea, Inssausti y Cerda (2013).

Most of the patients in our study had a nasogastric tube for enteral nutrition. The study carried out in Spain by Yemlahi (2014) evaluated complications related to nasogastric tube insertion, such as infections, diarrhea, vomiting, constipation, pulmonary aspiration, tube dislodgment, tube obstruction, hyperglycemia and electrolytic alterations, pneumothorax, pneumonitis, among others.

According to researchers, elderly persons with an average age of 76 in intensive care present difficulty swallowing. Although the age average for our study was 73 years, our patients showed the same risk due to old age. Scientific evidence points out that, to avoid complications in patients with NGT, nurses must comply with the following recommendations: estimate daily gas-

tric residuals, verify tube placement, use precautionary standards, among others (Yemlahi, 2014).

Finally, the patients readmitted to hospitals show a 12.7% higher chance of CLABSI infections than those who were not readmitted, and readmissions were associated to CLABSI in our study. Centers for Medicare & Medicaid Services (CMS) in the United States started publishing information on patients readmitted to hospitals within 30 days showing certain medical diseases (Kassin, Owen, Pérez, Leeds, Cox, Schnier, & Sweeney, 2012). Kassin et al (2012) carried out a study which measured readmission risk factors within 30 days for general surgery patients.

For this purpose, the Patient Protection and Affordable Care Act came into effect in March 2010, which makes hospitals accountable for patient readmission within 30 days after discharge for certain diseases, among them surgical infections and CLABSI (Kassin et al, 2012). This law is already implemented in Puerto Rico, and Medicare is already reducing reimbursements as hospitals are legally obligated to report all readmissions. This situation is already having an economic impact on hospitals, which points to the importance of reducing hospital acquired infections.

According to a study by Kassin et al (2012), 16.6% of Medicare beneficiaries subjected to major intestinal surgery were readmitted for gastrointestinal problems, and only 6.4% were readmitted for post-surgical infections. The authors identified an increased risk for post-surgical conditions, with a 16.9% readmission rate. High risk factors included in the study were the following: gender (women), obesity, non-programmed surgeries, and patients with prolonged stays. There is little information on readmitted patients related to CLABSI. In Puerto Rico, there is no information on this, but our study hints that the cause for most patients' readmissions is in accordance with Kassin et al's findings or are due to infections acquired within 30 days after admission, considered Hospital Acquired Infections (HAIs).

Sandoval, Guevara, Torres y Viloria (2013) studied HAIs in a Venezuelan hospital (developing country) with the purpose of determining the frequency of HAIs associated to CVC use in patients. They studied 31 patients who had a central venous catheter inserted during surgery services, adult emergencies, medicine and intensive care, and the dialysis unit. The results of the previously mentioned studies indicate that 41.9% of patients had some acquired infection related to catheter use, bacteremia being the most frequent with a rate of 46.1%. The researchers also pointed out that the unit with the greatest incidence was the intensive care unit with 30.8%. In accordance with our study, one of the greatest risk factors was amount of days with CVC. They concluded the study providing recommendations regarding the importance of documenting the use of adequate techniques and proper catheter placement and management by medical and nursing personnel in patients' files.

An important factor according to scientific evidence to reduce the risk related to patients' stay in these critical areas is the reduction of devices to avoid complications and deaths.

When the studied hospitals were compared, the same situation was found with a significant variability observed in surveyed participants with respect to their choice.

Significant differences were seen regarding knowledge of personnel by gender in three items: item 1, which measured how often catheters should be routinely changed, number 3, which measured how often pressure transductors and tubes should be routinely changed, and number 6, regarding the recommended disinfectant.

No significant differences were seen with respect to nurses between those with post-graduate studies and those without, or between hospital of origin. A correlation was found between the amount of time the professional worked in ICUs and the global knowledge score on evidence-based practice for the prevention of infections related to CVCs.

A correlation was found between the variable "education time of nursing personnel on the prevention of hospital acquired infections (HAI)" with the global knowledge score regarding evidence-based guidelines for the prevention of CVC-associated infections, a positive and weak correlation.

These results should aid in the exploration of the knowledge the studied personnel has in the implementation of better, evidence-based practices to avoid infections caused by the management and maintenance of CVCs. Clearly, they allowed us to infer that they do not possess the knowledge or at least have many doubts regarding correct practice. That, in turn, allowed us to infer that there is not an acceptable degree of adherence.

In the Future of Nursing report, the Institute of Medicine (2011) stated that nurses should strive for higher levels of education and training to respond to the demands of a developing healthcare system and to satisfy the changing needs of patients. Everyone should advocate to include the nursing profession in the emergent care delivery models through the demonstration of education.

According to the PARISH model (Kitson, Rycroft-Malone, Harvey, McCormack, Seers & Titchen, 2008), evidence-based practice depends on the strength and mutual relationship of evidence, context and facilitation. Establishing that implementation is more likely to be successful if the evidence is of high quality, scientifically robust and coincides with professional consensus and the needs of the patient; if the context is likely to change based on cultural sympathy, strong leadership and proper monitoring and feedback systems, and if there are the proper means of change with the contribution of an external expert and with internal facilitators (Kitson, 2008). The achievement of this implementation given the level of complexity depends on the type of process which should occur. A careful arrangement of the interrelation between evidence, context and facilitation including how this interaction oc-

curs at the different layers of the organization, the weight of each factor with regards to the possibility of carrying out evidence-based practice, whether the content of the model to be used is comprehensive, and whether it is well understood by the involved parties (Kitson et al, 2008). Continuing education can serve as a tool, along with organizational and individual factors, to positively influence innovation and the successful implementation of evidence-based practice (Yost et al., 2015)

A dramatic example was seen with project Pronovost upon the simplification of guidelines based on scientific knowledge to what is practically a checklist implemented in a well-organized, participative and motivational context which resulted in processes of adhesion, which in turn made it possible to save lives by reducing infections to practically zero.

Upon studying the two critical care units in the hospitals of the metropolitan area of San Juan, Puerto Rico, the situation described in the previous paragraph was not seen. A group of workers (nursing professionals) was surveyed through a thoroughly validated questionnaire, and the results point to doubts and deficient performance.

But the level of adherence could not be completely determined. We mentioned our intention of exploring knowledge and adherence through the tool used for this particular objective. A lack of knowledge was observed concerning adherence, so this exploration revealed the need to go beyond the instrument used.

The adherence shown by nursing professionals in intensive care units has therefore an important component concerning context. Kitson et al (2008) point to the importance of context when adherence is being evaluated.

According to Valiente (2015), knowledge and adherence has been facilitated or carried out using the following strategy: An Infection Prevention and Control Committee composed of an infectologist (president), an epidemiology nurse, an executive director, a nursing director, a bacteriology director, among others. This committee discusses the rate of infections acquired by patients, the working conditions of nursing professionals, and situations and problems related to healthcare. Valiente points out that all members must present all new, emerging scientific evidence in the committee for discussion, as for instance the latest revision of the Central Venous Catheter Patient Management Guidelines. The committee makes directors and leaders accountable or delegates on issues concerning rule monitoring and compliance, protocols and guidelines discussed concerning new evidence. The scientific evidence is validated, and how they will help reduce the rate of infection is discussed, including CLABSI.

It is insufficient for practices to be validated with scientific evidence, or whether or not they have been successful in other contexts; rather, they must be evaluated in the research environment (Gómez Urquiza, Hueso Montoro, Reina Leal, Hernández Zambrano & Amezcua, 2014).

Our study shows similarities with other studies reviewed. In an investigation carried out in Belgium, doctor S. Labeau (2008) found that evaluated nursing personnel had numerous erroneous conceptions on the management and maintenance of CVCs.

In a study by Jardim, Lacerda, Soares De Jesus and Nuñes (2013), the authors found 0.0% compliance with appropriate central venous catheter insertion practice, 91.6% for evidence concerning CVC insertion and management, 51.5% for adhesion to care, maintenance and preparation for CVC and its appliances, and 10.7% for the practice of hand hygiene when carrying out procedures for the care and maintenance of CVCs.

Adherence of nursing personnel to recommendations and guidelines has been well-studied from the perspective of establishing interventions to ensure guidelines (Flodgren et al, 2013). Practically all reviewed studies have shown deficiencies, doubts and poor performance, implying the need for better intervention strategies.

The greatest domain of adherence was in the clinical domain for both hospitals. An average of approximately 13 nursing professionals complied with the actions and recommendations of the clinical domain. An average of approximately 5 and 4 nursing professionals complied with the actions and recommendations in the domain of facilities and strategies, respectively.

Another finding was a negative correlation with regard to experience in ICUs and adherence to the clinical domain. The more time the nurse had spent in intensive care, the lower the adherence in the clinical domain for infection prevention with regard to hours of education. With relation to hours of training in infection control during the last twelve months, the great majority of participants indicated 4 hours; we may infer that these 4 training hours correspond to the mandatory continuing education in Puerto Rico for license renewal, where the topic is Management of Patients with HIV, AIDS and Hepatitis, within the topic of infection control. In Puerto Rico, this topic of Management of Patients with Central Venous Catheters was not part of continuing education and was available starting on December 2016.

The strategies for the prevention of infections related to central venous catheters have been developed in guidelines by the Center for Disease Control (CDC) since 2002. They were revised in 2009 and 2011. The CDC is recognized as a leading agent in the protection of health and security by all research studies as well as for its orientation to compliance with evidence-based practices. The CDC carries out a series of recommendations for the management of patients with central catheters, categorized according to existing scientific data (CDC, 2011).

In Puerto Rico, the Joint Commission (Hospital Accrediting Agency) has been more rigorous since 2006 in evaluating the compliance of one of its National Goals, the Management of Patients with Central Venous Catheters. To accredit hospitals, they are required to present strategies used for CLABSI

reduction. The rate of CLABSI patients are among the requirements so that they demonstrate the implementation of CDC recommendations. Both hospitals studied are accredited by the Joint Commission; however, not all CDC recommended actions and strategies are fully implemented for the management of patients with CVCs.

As pointed out by Marrero (2016), multiple strategies have been implemented in Puerto Rico for the reduction of infections related to CVCs, particularly in CLABSI, among which are: incorporation of the latest 2011 CDC Guidelines, development of workgroups for the discussion and implementation of these guidelines, the implementation of bundles for the insertion of central lines, among other recommendations. Also, according to Marrero, yearly education is offered to all nursing personnel, including doctors, regarding the management and prevention of infections in patients with CVCs. This continuing education must be demonstrated to the accrediting agencies as evidence of the strategy used to reduce the risks associated to CVCs.

According to Marrero, instructions were also given for the placement and management of central lines and quality improvement indicators were developed to measure the performance of nursing personnel and doctors with regard to the management of patients with CVCs. In hospital 1, no standardized documentation was found, unlike hospital 2. Not all hospitals in Puerto Rico use the checklists recommended as per scientific evidence to standardize nursing documentation in the management of CVCs. Some use them, but they are not part of patients' files (Diaz, 2016).

Rosenthal, Dueñas, Sobreyra, Ammar, Navoa, de Casares, Concepción and Villanueva (2013) carried out a study in four developing countries (El Salvador, México, the Philippines and Tunisia) as part of the International Nosocomial Infection Control Consortium (INICC). It used a multidimensional approach with the objective of reducing bloodstream infections associated to central catheters in 4 intensive neonatal care units. The sample consisted of 2,241 patients hospitalized in 40,045 days. During phase 1, active surveillance was carried out, and in phase 2 the multidimensional infection control approach of the INICC was put into practice. This included the following: a central catheter care "bundle", education, result surveillance, process surveillance, CLABSI rate generation and revival of infection control practice effectiveness. During phase 1, 2,105 catheters a day were registered, and 17,177 catheters per day in phase 2. After application of the multidimensional approach, catheter-associated bacteremia was reduced to 55% (Rosenthal et al, 2013). This study concluded that a multidimensional approach was associated with a significant reduction in CLABSI rates.

According to Varela, Sierra, Drake and Terol (2009), it insufficient to reduce CVC-related infection, but rather the aim must be to reduce them to zero. In Spain, the Ministry of Health and Social Policy (MSPS) started the Bacteremia Zero Project in 103 ICUs and implemented various patient safety

interventions, significantly reducing the bloodstream infection rate associated to CVCs by 62%. According to these authors, Spain was the first country to take this initiative, and was designated by the WHO as an exemplary program in the reduction of CVC related infection in ICUs.

In Scotland, Kelly, Green and Hainey (2015) carried out a study entitled Implementing a new teaching and learning strategy for the care of patients with central venous catheters. The authors point out that, according to evidence, educating and training health professionals is essential to avoid complications. They also point out that this approach has not been thoroughly studied. Results show that nurses felt safer after having participated in training outside the clinical setting, as it provided a safe place to practice without interruptions. The findings of this study suggest that working installations can provide a safe and effective environment for nursing professionals to develop trust and knowledge regarding the management of patients with CVCs.

The study has some limitations due to its transversal design, with which it is difficult to establish causal relationships which could be present before surveying the nurses. Similarly, an information bias could have occurred if the nurses erroneously interpreted the different questionnaires, but it should be noted that previously validated instruments were used and that they have shown good comprehension in previous studies.

On the other hand, analysis in two different time frames allowed for comparing possible variations in the studied variable, but evidently, only a longitudinal study with continuous follow-up throughout those years would have been able to establish greater certainty in the associations found. It is possible that events and modifications occurred between those two years in the practice environment of both hospitals which could have affected the evaluated outcomes.

Finally, patients' clinical information was taken from their clinical histories, and it is possible that some events such as the appearance of determined infections or the use of appliances, catheter substitution, bandage changes, etcetera, were inadequately registered, but that is a common limitation in this type of study.

5. Conclusions

Nursing personnel in ICUs did not demonstrate sufficient knowledge of CDC recommendations for the prevention and management of CVCs, regardless of the variables of education and experience, and there is no generalized adherence to the evidence-based recommendations for the management of these situations.

The implication these results have on the World Health Organization strategies are important from the perspective of multicomponent strategy design which includes not only knowledge, but also barriers and facilitators in

the practical context of nursing professionals for a successful implementation of these measures, which have such a significant impact on patients' health.

Moreover, the patients evaluated in this investigation presented particular clinical traits which increased the risk of infections associated to appliances, in this case CVCs. In addition to the central venous catheter, these patients also used other devices such as mechanical ventilators, urethral catheters, parenteral nutrition and nasogastric tubes, all of which imply an increased risk. The most common insertion area for CVCs was the jugular vein, followed by the subclavian vein. The unit of insertion was the ICU. Generally, the bandage was changed between 1 and 3 times. The average amount of days patients remained with the CVC device was approximately 14. This means that the recommendations for patient care set forth by the CDC are not followed. These patients remained in the hospital an average of 22 days, 12.7 in the ICU. Most of the patients acquired one or two infections during their stay at ICU, among them CLABSI.

Hospital 2 showed an increased frequency of CLABSI when compared with the country's average rate. For the period of 2012, there were more factors associated with CLABSI infection than in 2009. The factors associated with CLABSI infection during 2012 were readmission, length of stay at ICU, days with mechanical ventilators, days with CVCs and days with nasogastric tubes. The factor most closely associated with CLABSI infection in 2009 was length of stay.

The risk of CLABSI infection rose in function of readmission factors, days with nasogastric tube and days with CVC. The nursing professional in intensive care settings did not demonstrate full knowledge of the CDC recommendations for the prevention and management of CVCs, independently of their educational background or experience. The educational background and experience of nurses, such as length of experience in intensive care settings and hours of education on preventing infections, showed a weak correlation with the global knowledge of the CDC recommendations for the prevention and management of CVCs.

Nursing personnel in intensive care settings of both hospitals failed to fully implement the actions and strategies recommended by the CDC for the management of critical patients with central lines. The greatest domain of adherence by nursing staff was clinical. Time of experience of nursing staff in intensive care units showed a negative and very weak correlation with staff adherence to the clinical domain. Nurses' hours of education on infection prevention showed a negative and very weak correlation with staff adherence to the clinical domain. A correlation was found between years of experience of nurses working in intensive care units and the domain of facilities. No correlation was found between staffs' adherence to CDC recommendations and the global knowledge score.

Nursing professionals participate in continuous learning pursuant to better practices, including evidence-based decision making, which contributes to improve the quality of patient care. The nurses' technical skills and critical thinking by the patients' bedside are not, by themselves, sufficient to maintain an evidence-based practice setting. Nursing professionals are responsible of guaranteeing the competencies associated with important implications for continuing education (Ingwerson, 2016).

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