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Training, management, and quality of nursing care of vascular access in adult patients: The INCATIV project

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Sonia Casanova-Vivas[1,2], José-Luis Micó-Esparza[3], Isidro García-Abad[4], Enrique-Bernardo Hevilla-Cucarella[5], María-Luisa Ballestar-Tarin[2], José-María Blasco[6] and Pablo García-Molina[2]

Abstract

Background: More than one billion of peripheral venous catheters are inserted into hospitalized patients every year. This study sought to identify the status of nursing care in vascular accesses in different hospitals and to evaluate the impact of a series of informative and formative interventions aimed at their care.

Methods: Quasi-experimental, multicenter study. A total of 54 nursing professionals of 19 hospitals participated. The intervention consisted of informative talk and three training sessions related to the care and maintenance of vascular accesses and intravenous therapy in the hospital-admitted adult population. This was delivered in four years, with eight periodic cross-sectional assessments conducted before and after each intervention. To assess quality of nursing care in vascular accesses and intravenous therapy, a quality indicator called Standard Variable (VES), was developed and validated with the Delphi methodology.

Results: A total of 21,108 patients, aged 64.0 years (SD 18.3), were assessed, of which 78.3% (16,516) had some type of vascular access inserted. An average of 22.1% (95% CI: 21.4–22.7) were classified as optimal. In total, 3218 nursing care professionals took part in the training activities. The VES indicator grew steadily throughout the study, raising from 7.8% to 37.6%. Changes were statistically significant between those time points in which one of the described interventions was delivered; however, there were no significant changes between time points with no intervention.

Conclusions: This study supports that continuous training interventions can produce improvements in the quality of nursing care and reduce complications in patients with vascular accesses. In addition, the VES indicator was a useful and simple tool to measure quality, but the experience with its use suggests continuous research in the search for standardized indicators that objectify the evaluation and evolution of care.

Keywords

Vascular access, intravenous therapy, quality, nursing care, training

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[1]Servicio de Prevención de Riesgos Laborales, Conselleria de Sanidad Universal y Salud Pública, Valencia, Spain
[2]Facultad de Enfermería y Podología, Universitat de València, Valencia, Spain
[3]Hospital Arnau de Vilanova, Conselleria de Sanidad Universal y Salud Pública, Valencia, Spain
[4]Hospital General Universitario de Elche, Conselleria de Sanidad Universal y Salud Pública, Valencia, Spain
[5]Servicio de Análisis de Sistemas de Información Sanitaria, Conselleria de Sanidad Universal y Salud Pública, Valencia, Spain
[6]Group of Physiotherapy in the Ageing Processes: Socio and Healthcare Strategies, Departamento de Fisioterapia, Universitat de València, Spain

Corresponding author:
Enrique-Bernardo Hevilla-Cucarella, Servicio de Análisis de Sistemas de Información Sanitaria, Conselleria de Sanidad Universal y Salud Pública, Carrer de Misser Mascó, 31, 33, Valencia 46010, Spain.
Email: ehevilla@gmail.com

Introduction

More than one billion of peripheral venous catheters (PVC) are inserted into hospitalized patients every year.[1] In Spain, the Nosocomial Infection Prevalence Study (EPINE) reported that the use of vascular catheters has been increasing steadily since the 90's.[2] The latest data, published in 2019, indicated that 75.3% of patients requiring medical treatment had a PVC inserted, while 10.9% of patients' had central venous catheters (CVC) insertion.

From the time a catheter is inserted until it is removed, minor complications (e.g. discomfort, limitation of mobility, etc.) and/or serious complications can compromise patient safety. The latter can be mechanical and infectious. Depending on their location, they are local-proximal (infection of the puncture site, thrombophlebitis), distant (arthritis, endocarditis, etc.), or general (bacteremia).[3,4] In case of CVC, primary nosocomial bacteremia is the most serious complication, reaching 1.53% of primary bacteremia/1000 CVC days in 2018.[5] As for PVC, phlebitis is the most important complication, although its appearance can vary between 2.3% and 60%.[6]

The nurses, in their clinical practice, are responsible for the insertion, care and maintenance of vascular accesses, as well as for the prevention of complications; therefore, they need to comply with evidence-based recommendations. In this situation, Centers for Disease Control and Prevention (CDC) have provided multidisciplinary guidelines, recommendations, and strategies to improve compliance with the recommended practices.[7] The effectiveness of some of these initiatives (including monitoring, education and training programs, or the creation of vascular access teams)[8–12] has been studied, leading to some positive results[13]; however, no strong conclusions have been drawn. Other studies described compliance,[1,8] although none evaluated its clinical impact. What multiple studies agreed on is the great variability in clinical practice, and the need to implement bundles to increase compliance with recommendations.[14–16] Therefore, the availability of indicators that allow to objectify relevant aspects of assistance, establish comparisons, propose objectives, and create a culture of evaluation and improvement of assistance has become essential.[17]

Given the above factors, this multicenter study, lasting 4 years, conducted in Spain, and developed within the framework of the INCATIV project (i.e. INdicadores de CAlidad en Terapia IntraVenosa or in English, quality indicators in intravenous therapy), was designed with the following objectives: first, to identify the status of nursing care in vascular accesses in different hospitals and second, to evaluate the impact of a series of informative and formative interventions aimed at their care. For this, a quality indicator, the Standard Variable (VES), was developed and validated, as detailed in this manuscript.

Methods

Design and setting

This was a prospectively designed, quasi-experimental, multicenter study, with eight periodic cross-sectional assessments performed between March 2009 and March 2013; specifically, four were performed pre-intervention and four were post-intervention. Overall, the interventions consisted of, first, informative, and later, training activities, aimed at nursing professionals. The activities were related to the care and maintenance of vascular accesses and intravenous therapy in the hospital-admitted adult population. A total of 19 hospitals in the Valencian Community (Spain) participated in this study, called INCATIV. A Management Group (MG) was established as a foundation for information and guidance. This consisted of a team of nurses specialized in vascular access. The MG reached a consensus on the timeline and schedule of the cross-sectional assessments, and the structure and content of the training interventions. Due to the lack of an objective indicator used consistently in the scientific literature, the MG decided to set the procedures for the creation of a new care indicator, that was referred as Standard Variable or VES. This indicator was designed and used to control and assess the quality of care in the participating centers.

Nursing professionals engaged in the care and maintenance of vascular access of hospitalized patients were covered by the project, excluding those patients admitted for less than 24 h, those admitted to the Emergency Units, Psychiatry, Day Hospital, Home Units or Unit of Surgery Without Admission, and patients under 16 years old.

Procedures

Definition and development of VES variable. The VES was designed applying the Delphi methodology.[18] Six nursing professionals, who belonged to MG and experts in vascular access care, participated in the iterative process. This was designed in three rounds, to establish the appropriate criteria to consider optimal vascular access care. The start point were the usual evaluation criteria of the Intravascular Catheter Insertion, the care procedures established in the Official Manual of General Procedures of the Regional Ministry of Health in Valencia,[19] and CDC criteria.[7] After three iterations, the group agreed that the VES had to consider a series of 10 criteria, which can be consulted in Table 1. Depending on whether each of them was met, the general state of venous accesses was classified as optimal or not optimal. The VES per center and per section was later calculated as the ratio between the "total number of hospitalized patients with vascular access considered optimal" compared to the "total number of hospitalized patients with vascular access."

Table 1. Criteria and operative definition of an optimal vascular access according to VES quality indicator.

Criteria (yes/no)	Operational definition
1. Appropriate dressing	The dressing used was a transparent dressing, or if the patient was sweating, a gauze was used
2. Date recorded on the dressing	The date the catheter was inserted was labeled and visible on the dressing
3. Dressing well stuck	The dressing was well adhered to the skin, not peeled off
4. Dry dressing	The dressing was dry, not wet
5. Clean dressing	The dressing was observed to be kept clean
6. Comfortable dressing	The patient did not report any discomfort regarding the dressing
7. Last change <7 days	The dressing had been changed in the last 7 days
8. Visible insertion point	The catheter insertion point was perfectly visible
9. No open access	There was no open access either at the connection to the catheter or along the infusion system
10. Observable signs of phlebitis	Absence of induration, pain, or signs of inflammation at the insertion site or along the catheter path

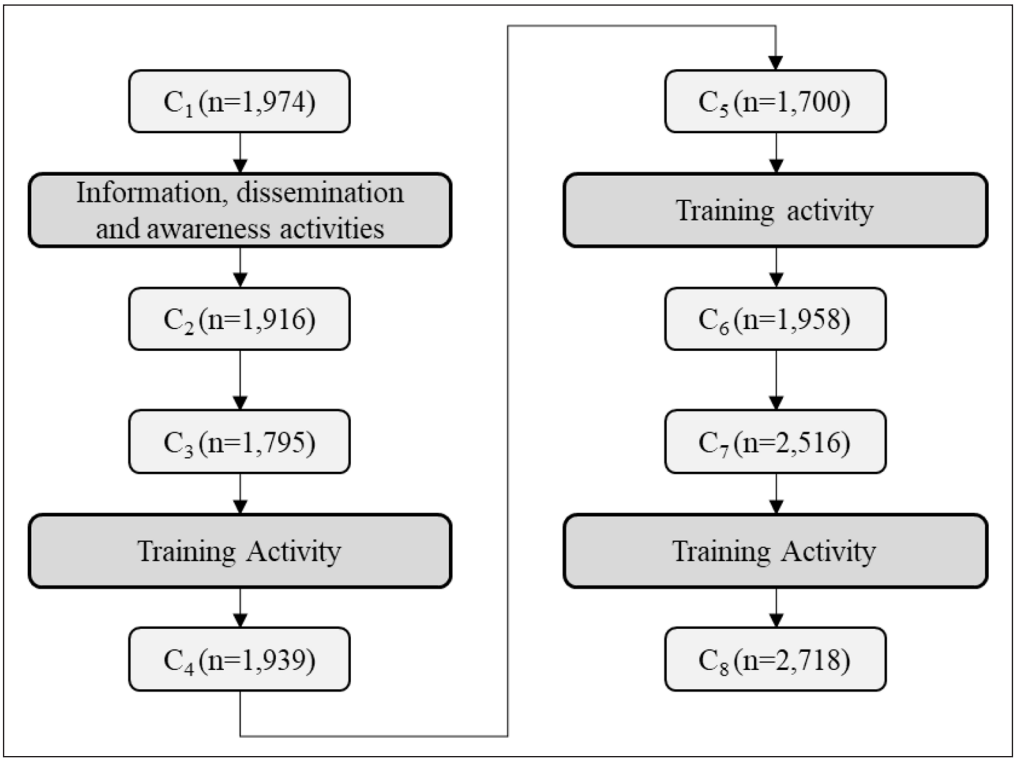

Figure 1. Study flowchart. C_i (i = 1–8) represent cross-sectional time points for assessment.

Design, flow of the intervention and assessment timeline. The information and training interventions were designed by the MG and transferred to field research collaborators (FRC, see next section) of each participating hospital. FRCs were in charge of the training activities adapted to the context of each center and unit. Before (pre-intervention) and after (post-intervention) each one (four in total) of these activities, the eligible admitted patients were assessed (cross-sectional assessments, hereinafter C_i, with $i = 1 \rightarrow 8$), as the flow represented in Figure 1 summarizes.

The interventions were as detailed: after baseline or C_1 assessment, the first activity was conducted; this was primarily informative in nature, and consisted of outreach activities in the participating hospitals. Posters were created, printed, and distributed. Overall, the resources were aimed at informing about the objective of the study, and used as an awareness campaign in the care and management of intravenous therapies. The intervention included a personalized delivery (with acknowledgment of receipt) of the chapter on the insertion and maintenance of vascular catheters, extracted from the Procedures Guide of the Health Department of the Valencian Community,[19] to each of the nurses from the participating services. The following interventions were 1-h training sessions delivered at each hospital. The module consisted in reinforcing the Bundle recommendations of the study.

Three months after C_1, the results were evaluated (i.e. at C_2). This methodology based on cross-sectional assessments, and consisting of (1) baseline evaluation, (2) intervention, and (3) post-intervention evaluation was repeated, first, with a frequency of 6 months, and then annually in the years 2011, 2012, and 2013, according to what is represented in the Figure 1. Originally, nine hospitals took part in the project. Subsequently, between C_4 and C_5, three more hospitals were incorporated; then, between C_6 and C_7, four more hospitals joined the project, with a total of 19 participating hospitals.

Team for data collection. For data collection, one researcher (nurse) was designated as the research coordinator (RC), and one or more FRCs were also designated at each participating hospital. The RCs were responsible for the training of care nurses, as well as for ensuring compliance with the recommendations. The FRCs were in charge of collecting data on-site, and introduce them into a computer program created for this purpose designed to provide real-time feedback through a series of descriptors and graphics. As for the data collected, these included (1) sociodemographic characteristics and (2) data related to vascular accesses, including type of venous access, location of the IV line, catheter gauge size, type and condition of the dressing, record of the date of insertion, origin of the venipuncture (i.e. service/unit in which the catheter was originally inserted), observation of the insertion point, and presence of phlebitis, according to the Maddox scale.[20,21]

Data analysis. Descriptive and inferential analyses were conducted with the SPSS 22 and Microsoft Office Excel programs, licensed by the Universitat de València. Confidence intervals were set at 95%. The records from cross-sectional assessments C_1 to C_8 were analyzed. Descriptive synthesis included calculations of absolute and relative frequencies, and percentages for categorical variables. Rates, means, and standard deviations were calculated for continuous variables. Contingency tables, frequency tables, and bar and line graphs were used to present results. The inferential statistics included normality contrast tests using Kolmogorov-Smirnov, Chi square test, and *F*-test for independent samples comparison.

Ethics

This project adhered to the Helsinki Ethical Guidelines and subsequent modifications, complying with the applicable data protection laws. An exemption to request informed consent was approved by the Research Ethics Committee of the Ribera Health Department on July 4, 2009. Data were anonymized in origin, with numerical codes.

Table 2. Sample characteristics (C_1 to C_8).

Demography	
Age (y)	64.0 (18.3)
Sex (*n*, % men)	10,931 (51.5%)
Type of catheter (*n*, %)	
CVC peripheral insert	1170 (2.4%)
CVC	1170 (7.1%)
Parenteral nutrition	297 (1.8%)
PVC	14,622 (88.7%)
Location (*n*, %)	
Forearm	5077 (30.8%)
Back hand	3851 (23.3%)
Wrist	3251 (19.7%)
Arm flexure	2763 (16.7%)
Caliber (*n*, %)	
18G	3996 (24.4%)
20G	339 (32.6%)
22G	1499 (9.1%)
Not observed	5551 (33.9%)

CVC: central venous catheter; PVC: peripheral venous catheter.

Results

During the study period, the project reached a coverage of 5600 hospital beds, and 4480 nursing professionals who intervened in the care and maintenance of the vascular accesses of the admitted patients. Fifty-four nursing professionals participated in the study. A total of 21,108 patients, with a mean age of 64.0 years (SD 18.3), were assessed throughout the study. Overall, 51.5% (10,931) of them were men. The mean global hospital occupancy rate was 76.8%. According to the records, 78.3% (16,516) of the patients had some type of vascular access inserted. The number of participants at C_i is shown in Figure 1. Also, Table 2 lists the main characteristics of the vascular accesses. The results suggested that an average of 22.1% (95% CI: 21.4–22.7) of the intravenous lines were classified as optimal, according to VES indicator. A high inter-hospital variability was also revealed, since 11 out of the 19 participating centers did not overcome this average figure (see Figure 2).

Effects of interventions

In total, 3218 nursing care professionals took part in the training activities designed for the study, and carried out between C_3–C_4, C_5–C_6, and C_7–C_8. This figure represents 72% of the nurse workforce responsible for the care of vascular accesses in the participating hospitals. Table 3 shows the evolution of compliance with the recommendations for optimal care of vascular accesses from C_1 to C_8. The VES indicator evolved linearly throughout the study, as shown in Figure 3. Overall, changes in VES were incremental and statistically significant between those time

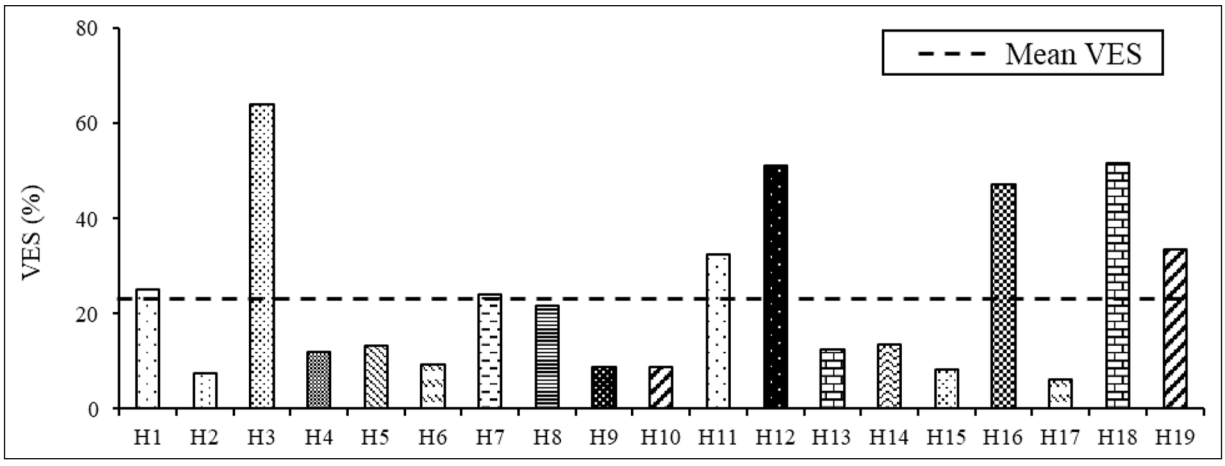

Figure 2. VES indicator estimated per participating hospital. Bars refers to the result at each participating hospital.

points in which one of the described interventions was delivered; however, there were no significant changes between time points with no intervention. Specifically, the outreach activities, dissemination, and information campaign resulted in a baseline change of VES indicator of $\Delta_{VES(C1\rightarrow C2)} = +2.9\%$; $p < 0.002$. Subsequently, there was a non-significant decline of the indicator: $\Delta_{VES(C2\rightarrow C3)} = -0.9\%$; $p = 0.402$. The following workshops resulted in a significant increase of the indicator: $\Delta_{VES(C3\rightarrow C4)} = +17.8\%$; $p < 0.001$. Then, the change was not significant $\Delta_{VES(C4\rightarrow C5)} = -5.1\%$; $p = 0.006$, as might be expected. This was followed by a further increase due to the training workshops given after C_5, taking into account that five new hospitals joined the project ($\Delta_{VES(C5\rightarrow C6)} = 1.9\%$). The same was observed in subsequent cross-sectional assessments (with no training: $\Delta_{VES(C6\rightarrow C7)} = 2.4\%$; $p = 0.077$; with training $\Delta_{VES(C7\rightarrow C8)} = 10.7\%$; $p < 0.001$), until reaching 37.6% of records considered optimal.

Discussion

The implementation of the so-called VES quality indicator allowed us to successfully objectify and compare the quality and safety of care of a total of 16,516 vascular accesses, which were evaluated in 21,108 patients, admitted to the 19 participating hospitals, during a 4-year period. Based on this, this study supported that the implementation of a series of periodic information and training sessions for nursing professionals improved the quality and safety of vascular accesses, with a VES baseline evolution from 7.8% to 37.6%.

There were significant improvements after the first informative activity (delivery of the protocol and posters), but also after each one of the subsequent training. By contrast, there was no significant VES variation between those cross-sectional assessments in which no training was delivered. This suggested that (1) information and training had a positive impact on improving and increasing the safety and quality of vascular accesses, that (2) the content and competences acquired by the professionals after each intervention were maintained over time, at least, until the next cross-sectional assessment, and that (3) each new training session produced incremental benefits in the skills of the professionals in this area, as demonstrated by the upward linear evolution of the VES indicator throughout the 4 years of the study.

One aspect to consider is that the greater increases in VES occurred after the training sessions rather than the information session. Indeed, some studies had already suggested that informative sessions could have a low impact; this was the case of Morse and McDonald's[13] study, whose education program based on posters alone failed. A multimodal program is more likely to be successful, as demonstrated by repeated long-term failure of hand hygiene campaigns over many decades. Improvement in hand hygiene behavior is only observed when extensive efforts are devoted to the implementation of recurring education campaigns promoting hand hygiene.

As for the training sessions, these were based on care bundles oriented to the prevention and improvement of the maintenance of vascular accesses. Several care bundle projects resulted in improved outcomes, which would reinforce our findings.[11,22] Bundles simplifies long action guides into reminders or "training pills," and improves staff adherence to good practices.[16] However, while care bundles effectively reduces bacteremia rates associated with CVC, bundles related to PVC have an impact still uncertain.[16] What seems important to emphasize is that protocols and bundles can inspire, motivate, and strengthen the nurses who work in the units with the aim of improving the results of the patients.[23]

An important factor that could influence bundle compliance was the availability of real-time feedback. This study offered to nurses the possibility to check the degree of compliance with recommendations in real time through graphical results. This allowed to compare units and

Table 3. Bundle recommendations vascular access (VA) care.

Cross-sectional point (Ci)	Intervention 1		Intervention 2		Intervention 3		Intervention 4		*p*-Value
	Baseline (C_1)	Post1 (C_2)	Pre2 (C_3)	Post2 (C_4)	Pre3 (C_5)	Post3 (C_6)	Pre4 (C_7)	Post4 (C_8)	
Total VA evaluated	1974	1916	1795	1939	1700	1958	2516	2718	
Use of transparent dressing	851 (43.1%)	925 (48.3%)	840 (46.7%)	1223 (62.9%)	1047 (61.4%)	1209 (61.6%)	1611 (63.9%)	1945 (71.3%)	<0.001
Record of insertion date	285 (14.4%)	354 (18.5%)	403 (22.5%)	830 (42.8%)	626 (36.8%)	875 (44.7%)	1200 (47.7%)	1710 (62.9%)	<0.001
Visible insertion point	869 (44%)	843 (44%)	807 (45%)	1327 (68.4%)	1071 (63%)	1225 (62.6%)	1654 (65.7%)	2047 (75.3%)	<0.001
Last day of dressing change (<7 days)	1901 (96.3%)	1880 (98.1%)	1768 (98.5%)	1914 (98.7%)	1668 (98.1%)	1918 (98%)	2472 (98.3%)	26,921 (99%)	<0.001
Use of keys	1613 (81.7%)	1581 (82.5%)	1461 (81.4%)	1623 (83.7%)	1484 (87.3%)	1645 (84%)	2041 (81.1%)	2304 (84.8%)	<0.001
Presence of phlebitis	96 (4.9%)	58 (3%)	77 (4.3%)	61 (3.1%)	48 (2.8%)	74 (3.8%)	115 (4.6%)	117 (4.3%)	0.003

Data are given as *N* (%).

centers, the nursing professionals being aware of whether their daily task was carried out under the same quality standards as those of their same hospital category. In a review of 47 studies that evaluated interventions to improve care and aseptic central catheter placement, it was found that educational interventions had a longer effect when combined with feedback, in addition to other relevant aspects, such as whether the percentage of baseline compliance was low, if practical sessions were repeated frequently, if staff participation was active, and if there was a motivation for change.[24]

Overall, the intervention results were satisfactory, but it becomes necessary to note that the average figure on the optimal status of the vascular accesses of all the records obtained in the eight cross-sectional assessments, only reached a rate of 22.1% (CI: 21.4%–22.7%) vascular accesses classified as optimal. Furthermore, the rate was highly variable between hospitals, with more than half of the centers with a VES rate below average. We can only explain this variability in qualitative terms, speculating that perhaps it could be due to possible differences in terms of involvement and commitment to the project of the different supervisors, managers and staff of the participating centers, as usually occurs in multicenter studies.[25] Having said this, a deeper understanding on the causes that could have motivated the differences found would be of interest.[16]

If we contextualize with the existing literature, it is well established that an optimal compliance with the protocols is an important measure in the prevention of complications related to intravenous catheters.[26] The phlebitis detected in this study was 3.1%, a figure much lower than that reported by other studies (mainly assessing incidence though).[27] The importance of having information on the data related to this type of care lies in the high rate of vascular access in patients admitted to hospitals. In this study, we assessed 78.3% of patients, a figure higher than that of the available bibliography.[3] Overall, 88.7% of the vascular accesses were PVC, a rate very similar to the one found in Spain by the One Million Global-PIVC study in 2015 (a worldwide study on the prevalence of peripheral venous catheters).[3] And most importantly, an important clinical impact of the project was observed; as an example, data such as the use of transparent dressing, which increased by 28.4% between the first and last cross-sectional assessment, or as the record of the date of insertion of the vascular access, which increased by 48.5% in its compliance. Our results warrant future studies oriented to develop training and follow-up strategies, such as those proposed to improve the management and quality of vascular accesses. In addition, to work on the development of future indicators that provide information that is not only dichotomous on the quality of vascular accesses.

Our study comes with limitations. The quality of vascular accesses was directly evaluated by healthcare professionals in situ; this introduces an unavoidable observer/

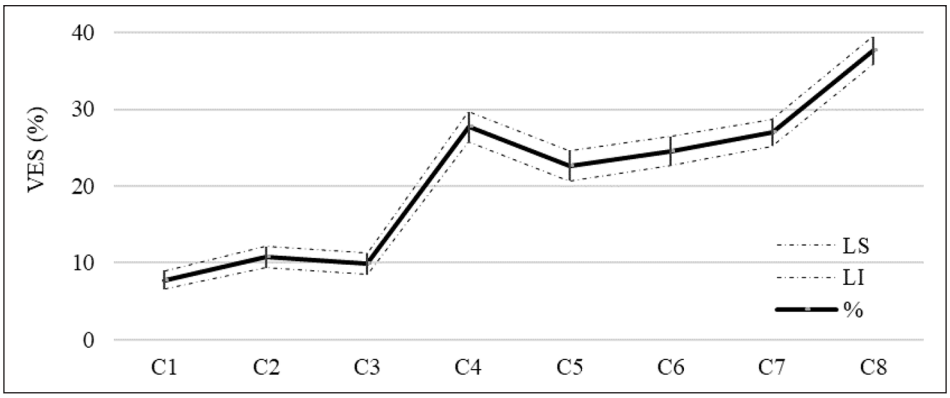

Figure 3. Evolution of VES indicator throughtout the study. Informative and training activities were delivered between C_1 and C_2, C_3 and C_4, C_5 and C_6, C_7 and C_8, involving significant changes (95% CI) in VES % value ($p < 0.05$). No intervention was delivered between C_2 and C_3, C_4 and C_5, C_6 and C_7, with no significant changes in VES value ($p > 0.05$). Dotted lines represent 95% CI. Abbreviations: LS: 95% CI superior limit; LI: 95% CI inferior limit.

evaluator bias. Yet, we put our efforts on minimizing the impact by causing the field researchers to exchange their work units to carry out the data collection and the date of data collection was not made public in any court. Some centers joined the study over the 4-year period; this should be taken into consideration when interpreting results. Findings related to the effectiveness of interventions were based on prevalence data, since it was not possible to study the patients longitudinally, due to the consequent complexity of the study covering so many hospitals, and the increasing number of resources and time that would be needed. We believe that future incidence study would likely provide better indicators on the frequency of adverse effects.[16] As an example, phlebitis is found in 12.9% of the adverse events detected (EAPAS 2008) and according to the Infusion Nursing Society, an acceptable rate of phlebitis would be around 5%.[6] Having said that, similar studies have also supported that prevalence studies, carried out at the patient's bedside before and after interventions, are an adequate instrument to measure improvements in compliance with care.[8,10,28] Therefore, our study allowed to observe the impact of the training activities accompanied by continuous monitoring in the improvement in compliance with the recommendations on the care and maintenance of vascular accesses. On the other hand, factors such as adequate hand hygiene, the type of drug to be administered or the patient's own conditions could be considered in future research. Data collection was at the patient's side, without consulting medical history, which allowed a high volume of data collection. Finally, most devices used over 3900 were 18 g future research should be explored using 20/22 g which may further contribute to risk reduction.

Conclusion

This study supports that implementing continuous training interventions, and providing real-time feedback of results, can produce improvements in the quality of nursing care and reduce complication in patients with vascular accesses. In addition, the VES indicator can be a useful and simple tool to measure the quality of nursing care in vascular accesses and intravenous therapy. However, the experience with its use suggests continuous research in the search for standardized indicators that objectify the evaluation and evolution of care.

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Author contributions

Sonia Casanova-Vivas, José-Luis Micó-Esparza, Isidro García-Abad: Study design, bibliographic review, work field, methods design, data interpretation, and final approval of the manuscript. Enrique-Bernardo Hevilla-Cucarella: Study design, methods design, data analysis and interpretation, and final approval of the manuscript. Pablo García Molina, José María Blasco, and María Luisa Ballestar: Methods design, data interpretation and analyses, manuscript draft, and discussion of final version.

Declaration of conflicting interests

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Ethical approval

Research Ethics Committee of the Ribera Health Department on July 4, 2009.

ORCID iD

José-María Blasco https://orcid.org/0000-0002-7663-9092

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