



## The effectiveness of an online training program in a nursing unit: extraction of blood cultures

Efectividad de un programa de formación online en una unidad de enfermería: extracción de hemocultivos

Eficácia de um programa de formação on-line em uma unidade de enfermagem: extração de hemoculturas

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### ABSTRACT

**Objective:** To assess the effectiveness of an online training platform for procedures among nurses in an internal medicine unit to reduce the number of contaminated blood cultures.

**Method:** This was a quasi-experimental pre-post intervention parallel group study. The sample consisted of internal medicine nurses in a tertiary hospital who participated in an online training program about blood culture extraction technique. Knowledge about the technique was measured pre- and post-intervention. Additionally, the study compared the number of blood cultures taken 6 months before and 3 months after the intervention.

**Results:** Forty-eight nurses participated. Pre-intervention knowledge was homogeneous among both groups, improving significantly after the online training program ( $p=0.0001$ ). The blood cultures taken prior to the training showed contamination levels above international standards; post-intervention, contamination levels fell by up to 3% in the intervention group. **Conclusion:** The educational intervention using the digital platform increased knowledge about the procedure and its application in clinical practice.

### DESCRIPTORS

Blood Culture; Contamination; Phlebotomy; Nursing; Health Education.

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## INTRODUCTION

Currently, blood cultures (BC) are still the gold standard for diagnosing and managing bloodstream infections, which can result in increased morbimortality<sup>(1)</sup>. However, BC contamination can cause errors in clinical decisions in infectious processes, negatively impacting patients, translating into longer hospital stays, retests, and even the use of inappropriate/unnecessary antibiotics, increasing hospital costs and reducing quality of care<sup>(2)</sup>.

Studies have suggested that BC contamination occurs before samples reach the laboratory, during their extraction and manipulation<sup>(1,3)</sup>.

Correct BC extraction techniques can reduce contamination<sup>(4)</sup>. Up to the present, proposals are aimed at education and capacity building of phlebotomists, a role usually played by nurses<sup>(5-6)</sup>. Such training has been conducted mostly in person, with all the inconveniences that this entails, such as the need for space, little freedom of professionals to carry out the activity, and elevated costs. The current literature suggests that online training can build capacities and skills at a similar or even higher level than in-person training, with lower economic impact and greater freedom for students<sup>(7)</sup>.

On the other hand, different authors state that heightened workloads and frequent turnover produce increased BC contamination<sup>(1)</sup>. These situations are common in intensive care units (ICUs), emergency services, as well as in internal medicine units<sup>(8)</sup>, with the latter receiving little attention in terms of implementing educational actions to reduce the incidence of contaminated BC. These internal medicine units receive fragile, polymedicated, and older patients with multiple pathologies. Age is an independent factor for BC contamination, as older adults tend to visit health services more frequently, generating a microbial biofilm on their skin, resistant to elimination, which increases the susceptibility of contaminating blood samples<sup>(1,5)</sup>. This justifies the need to conduct training programs with nurses who extract BC, with the goal of minimizing contamination.

In this context, the Elsevier Clinical Skills® (ECS) e-learning platform was created, which is based on a repository of procedures and protocols with different virtual materials. It can be accessed in any computerized form, including on smartphones, which is the most commonly used device by healthcare professionals<sup>(9)</sup>. Additionally, using the platform requires a subscription.

Considering the above, the authors decided it was important to assess the effectiveness of an online training platform about procedures and protocols in reducing contaminated samples in an internal medicine facility. The present study aimed to: 1. Analyze the variation in knowledge of internal medicine nurses at a tertiary-level hospital regarding the BC extraction technique before and after using the online platform. 2. Measure the impact of this intervention on the number of

contaminated blood cultures of patients admitted to an internal medicine unit.

## METHOD

### TYPE OF STUDY

Quasi-experimental pre-post intervention parallel group study.

### POPULATION

The target population consisted of internal medicine nurses at a tertiary hospital. The study was conducted between May 2015 and January 2016 at two of the four adult inpatient internal medicine units of a tertiary-level health center in the Community of Madrid. The two units and the participating nurses were chosen using simple random sampling.

### SELECTION CRITERIA

Inclusion criteria were: Nurses who worked in the selected unit; had an employment contract valid throughout the estimated time of study; volunteered participation; and signed an informed consent form. Professionals who were transferred to other services or who left during the period of study were excluded.

To assess the clinical repercussion in patients, all those who were submitted to BC extraction were included. Samples for which no result was obtained by the laboratory and BCs extracted during the educational intervention period were excluded.

### DATA COLLECTION

Phase 1: Before the intervention, professionals from the studied unit were recruited and tested as to their knowledge about the studied technique. In the six months prior to the study, the researchers collected data about patients who were admitted into the selected units and who had BC extracted, monitoring their results.

Phase 2: After the baseline was established, the educational intervention took place between October 26 and November 1, 2015, using the ECS platform. This training program consists of different educational resources (texts, images, and videos) and forms of evaluating (checklists and tests) the studied technique. The mean time invested by professionals in reading the material and watching the audiovisual materials was approximately 2 hours. The execution and visualization of resources on the platform was controlled by the platform administrator, who gave students reminders about the material they still had to cover. Once the training was completed, the students were allowed to take the post-intervention knowledge test. However, during the entire post-intervention time, the intervention group has the possibility of accessing all the resources, and they are asked to fill out a checklist at the end of each BC extraction to self-assess the technique. All BCs extracted during this period were not

considered for the analysis of any of the groups (experimental and control).

Phase 3: After the intervention, both groups were tested again regarding their knowledge, and the researchers compared the pre- and post-intervention scores and also the scores of the experimental and control groups. The different variables relative to BC and contamination were also analyzed.

The laboratory was informed about the study but kept blind in terms of the experimental and control groups and pre-and post-intervention samples, so that they could rigorously apply the criteria for a contaminated BC<sup>(10)</sup>. The samples were sent to the laboratory for analysis via a pneumatic tube system and the results were recorded in the hospital's electronic health records.

The knowledge test about the learned technique consisted of 15 multiple-choice questions, in which only one of the five possibilities was correct. The test content centered on three aspects: BC indication, extraction technique (including asepsis and necessary materials), and sample processing. Before the study, the knowledge test was analyzed for face validity by 10 experts raters, obtaining a kappa coefficient of 0.955. The knowledge tests were administered and evaluated using Google Forms, which allowed the test to be administered to students and the results sent directly to the form's administrator, keeping the assessment blind.

Professionals: Sociodemographic and work data and prior knowledge. Patients: sociodemographic and clinical

repercussion data (BC: extracted, positive, contaminated<sup>(10)</sup>, and number of days to obtain results).

## DATA ANALYSIS AND PROCESSING

Quantitative variables were analyzed by calculating means and standard deviations, while qualitative variables were analyzed using percentages. The groups were compared using the Mann-Whitney U test, and the pre-and post-intervention results, with the Wilcoxon test. Next, Cohen's d was calculated to establish effect size. For the categorical variables, the chi-squared test was employed. The confidence interval was set at 95%, with p-value < 0.05.

## ETHICAL ASPECTS

The professionals were informed about the study and asked to sign consent forms before volunteering their participation. This study abided by ethical considerations, as well as the directives set forth in Spanish Law 15/1999.

## RESULTS

### KNOWLEDGE OF PROFESSIONALS

Forty-eight nurses participated in the study, 26 in the experimental group, and 22 in the control group.

The professionals were young, mostly female, and with little work experience in the unit. No statistically significant differences were found in the characteristics of the groups, as shown in Table 1.

**Table 1** – Characteristics of internal medicine nursing professionals in a tertiary-level hospital in the Community of Madrid, Spain, 2015-2016

Variables	Experimental (N=26)	Control (N=22)	<i>p</i> -value
	Mean(SD)	Mean(SD)	
<b>Age (years)</b>	40.17(9.05)	39.61(7.88)	*0.949
<b>Gender</b>			
Male	11.5%	4.5%	**0.763
Female	88.5%	95.5%	**0.317
<b>Years of experience in the internal medicine unit</b>	2.38(1.8)	4.54(3.04)	*0.65
<b>Knowledge of BC extraction technique</b>			
<b>Mean score</b>			
Pre-intervention	4.62(1.57)	4.88(0.86)	<i>p</i> =*0.983
Post-intervention	<b>8.2(0.72)</b>	4.6(0.9)	<i>p</i> =*0.0001
<b><i>p</i>-value</b>	<i>p</i> =***0.0001		<i>p</i> =***0.106

N: population size; SD: standard deviation; BC: blood culture, \*Mann-Whitney U Test; \*\*Chi-squared; \*\*\*Wilcoxon test

Baseline knowledge scores were similar among both groups, less than 5/10. After the intervention, the experimental group's mean score rose to 8.2±0.72/10, while the control group's score remained less than 5 (4.6±0.9)/10.

Significant differences (*p*=0.0001) were observed between the experimental group's pre- and post-intervention test scores and the post-intervention scores of the experimental and control groups (Table 1).

The effect size for the increased post-intervention knowledge in the experimental group was:  $r_{bis}=0.60$  ( $z=-4.35$ ). On comparing the post-intervention scores between experimental and control groups:  $r_{bis}=0.85$  ( $z=-5.92$ ). Finally, for the pre- and post-intervention scores of the control group was  $r_{bis}=0.24$  ( $z=-1.62$ ).

## BC CONTAMINATION REPERCUSSION

A total of 909 BC were extracted from 387 patients. Pre-intervention, 583 BC were extracted and analyzed from 225 patients. Post-intervention, 326 BC from 128 patients were analyzed. No significant differences were found regarding both populations' characteristics (Table 2).

**Table 2** – Characteristics of patients admitted into an internal medicine unit pre- and post-intervention in a tertiary hospital in the Community of Madrid, Spain, 2015-2016.

Variables	Pre-general characteristics		p-value	Post-general characteristics		p-value
	Experimental (N=128)	Control (N=127)		Experimental (N=54)	Control (N=78)	
	Mean(SD)	Mean(SD)		Mean(SD)	Mean(SD)	
<b>Age (years)</b>	72.7±16.6	73±15.9	*0.762	73.8±15.6	72±16.6	*0.756
Age Women (years)	75±14.2	74.5±17.1	*0.679	78.12 10	69.94 17.1	*0.117
Age Men (years)	70.41±18.6	72.2±15.2	*0.656	66.1 20.3	73.4 16.3	*0.159
<b>Gender</b>		--			--	
Female	50.8%	35.4%	**0.057	63%	42.3%	**0.903
Male	49.2%	64.6%	**0.115	37%	57.7%	**0.002
<b>Length of hospital stay</b>	18.4±12	18.72±14.3	*0.632	18.9±10.1	18.5±21.8	*0.457
Stay Women	18.2±13.2	18.12±12.5	*0.564	18.5±13.9	15.5±13.6	*0.243
Stay Men	18.6±14.1	19.06±15.3	*0.824	19.6±19.6	20.6±26.1	*0.926
<b>Reason for extraction</b>						
Fever peak	74.2%	73.4%	**0.403	72.5%	79.5%	**0.104
Protocol	13.4%	14.1%	**0.392	15.9%	2.3%	**0.004
Extraction without fever	10.3%	9.8%	**0.735	11.6%	15.9%	**0.796
Catheter-drawn blood culture	2.1	2.7	**0.576	--	2.3%	--

N: population size; \*Mann-Whitney U test, \*\*Chi-squared.

Most of the BCs were sterile (Table 3). Among those in which microorganisms were detected, there was a significant percentage of contamination. A comparison between control and case post-intervention percentages showed 15 cases (9.5%) versus 5 cases (3%) of contaminated BC,

respectively. Among the experimental group, the percentage of contamination decreased from 6.6% (17) to 3% (5) between the pre- and post-intervention assessment. The control group saw a rise in BC contamination, from 4.6% (15) to 9.5% (15).

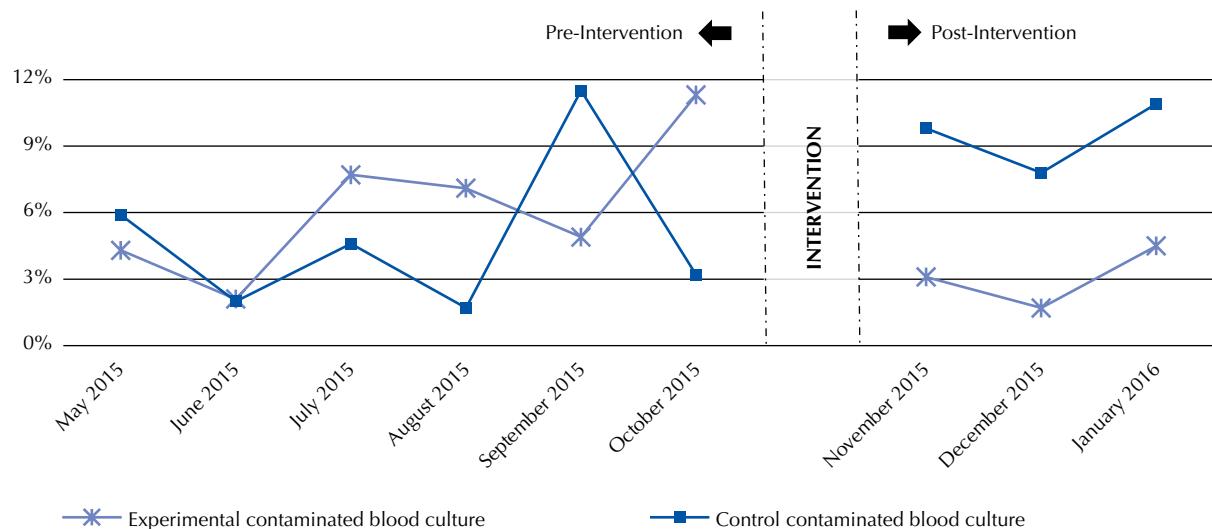
**Table 3** – Results of BCs from patients admitted into an internal medicine unit pre- and post-intervention in a tertiary hospital in the Community of Madrid, Spain, 2015-2016

Variables	Pre-intervention BC Result		p-value	Post-intervention BC result		p-value
	Case (N=258)	Control (N=325)		Case (N=168)	Control (N=158)	
Sterile culture	88.4% (228)	92% (299)	**0.002	88.7% (149)	82.5% (132)	**0.31
Microorganism cultivated	11.6% (30)	8% (26)	**0.724	11.3% (19)	16.5% (26)	**0.297
Contaminated BC of total	6.6% (17)	4.6% (15)	**0.683	3% (5)	9.5% (15)	**0.025

N: population size; BC: blood culture; \*Mann-Whitney U test; \*\*Chi-squared.

Figure 1 shows that, before the intervention, the experimental group presented higher levels of BC contamination than the control group. Post-intervention, contamination fell and reached quality standards, remaining lower than the control group for 3 months. Furthermore, the experimental group presented fluctuations in the three months post-intervention that were slightly higher than recommended levels

of BC contamination, even though the total mean score during this period fell within quality standards (Table 3). In turn, the control group presented fluctuations in both periods; however, after the intervention, the variations in the number of contaminated BC remained parallel to the experimental group and was much above the recommended standards of 3%<sup>(11)</sup>.



**Figure 1** – Variation in the percentage of contaminated BC per month. Pre- and post-intervention in a tertiary hospital in the Community of Madrid, Spain. 2015-2016.

## DISCUSSION

Blood culture contamination remains a generalized and current problem in the health field. The results both in the pre-and post-intervention phase for the control group in the present study reached figures that sometimes were twice as high as the recommended standards. Various authors have expressed the need to educate and frequently train professionals in charge of extracting and processing BC to avoid or reduce such contamination<sup>(12)</sup>.

It is difficult to compare interventions carried out by other authors to the present study's intervention, especially because of the heterogeneity in the origin and processing of the samples (venous puncture or catheter). Additionally, most interventions are carried out in emergency departments and intensive care units, with no specific references to hospital units that usually admit older individuals with repeated hospital stays, which are relevant factors, together with patient severity, that result in greater BC contamination<sup>(2)</sup>.

Another aspect worth noting is that the training and assessment described here were not conducted in person, but online, which together with the results obtained here and in other studies, supports the shift in forms of providing continuing education in hospitals, because online training can be conducted at any time, including with newly hired employees<sup>(13-14)</sup>.

Current reviews about educational methodology in virtual environments<sup>(8,15)</sup> point to the benefits of this type of education in comparison with traditional methodologies, with students placed at the center and teachers become facilitators of the process. Up to the present, studies about these methodologies have mainly taken into consideration their effectiveness, which in this study was expressed by the significant increase in the scores obtained by the experimental group ( $8.2 \pm 0.72$  points) when compared to pre-intervention scores ( $4.62 \pm 1.57$

points, Table 2), while the control group's scores remained stable between the pre- and post-intervention assessment ( $4.88 \pm 0.86$ – $4.6 \pm 0.9$  points). The effect size for the post-intervention scores of the case and control groups was  $r_{bis}=0.85$ , which is considered a large effect size. The same was true when comparing the pre- and post-intervention scores of the experimental group ( $r_{bis}=0.60$ ), while the opposite occurred in the pre-post effect of the control group, presenting only an effect ( $r_{bis}=0.24$ ). The improvement caused by the educational intervention presented large effect size, which was adequate in comparison with the training variation of professionals.

This improvement corroborates the data from another study<sup>(16)</sup> that compared three different types of learning methodologies: in person, e-book, and online platform. The pre-post assessment showed that in all cases, knowledge increased. On comparing online learning with traditional forms, there were no significant differences. Thus, the study concluded that any of the three forms of training are equally valid.

Additionally, the authors affirmed that training should aim not only at increasing knowledge, but that such knowledge must translate into the clinical environment<sup>(17-18)</sup>, or in the present study, into a reduction of contaminated BC. Another group of researchers<sup>(19)</sup> conducted a study with medical students from the University of Tasmania and found that individuals who were submitted to virtual methodology improved their theoretical knowledge and acquired skills. The same was true in the present study, with a clear clinical improvement in the reduction of BC contamination (6.6% vs. 3%) post-intervention that was not observed in the control group, which even increased its contamination level (4.6% vs. 9.5%).

A recent educational intervention carried out in a multi-purpose ICU based on conventional training methodology reduced BC contamination from 6% to 3.5%<sup>(20)</sup>, and similar to the study, the experimental group went from

6.6% and reached percentages that fell within best practice recommendations<sup>(11)</sup>.

Another study analyzed the effects of in-person training intervention about BC best practices with emergency service professionals in a New Jersey (USA) hospital<sup>(21)</sup>. The results showed a reduction between 1.96% and 0.3% of contaminated BC, relatively lower than the results obtained in the present study, which found a 3.6% reduction (6.6% versus 3%). However, those authors began with percentages that were lower than the ones in our units of study. Most research that carried out educational interventions of this sort reported a 3% to 4% reduction in contamination levels<sup>(21-23)</sup>.

Despite the improvement described above, the number of contaminated BC in the experimental group in the third month was slightly higher than quality standards, which may be due to the presence of other factors, as proposed by some authors<sup>(24)</sup>, who have stated that even though training is a very important element to avoid BC contamination, aspects such as work overload can produce poorer results. This is coherent with the results of the present study, for winter began in the third month, a period in which admissions spike in an internal medicine unit. This theory is supported by the parallel increase that was found between the experimental and control groups. Thus, longer follow-up assessments should be conducted among both groups, and learning reinforcements should be included whenever quality standards are not met.

In contrast, not all learning actions have shown positive impacts, such as observed in a study in South Korea<sup>(25)</sup>, which carried out an educational intervention with resident physicians to decrease contaminated BC. The authors used resources similar to those described in the present study (demonstration videos and clinical guidelines), in addition to practical simulations. The results presented an increase in knowledge about the technique, but it was not translated into reduced BC contamination. These differences were attributed to the fact that the sample consisted only of resident staff.

The same took place with an educational program proposed by Spanish researchers<sup>(26)</sup>, who conducted pre-post test technique to assess knowledge and who also monitored contaminated BC. The intervention was based on in-person sessions that exposed professionals to important aspects that help reduce BC contamination.

The results showed an improvement in knowledge (from 66.6/100 points to 85.7/100), as was the case in the present study; however, there was no reduction in BC contamination. In fact, some months after the intervention, contamination levels were higher than those registered pre-intervention.

Finally, this type of intervention has potential financial benefits. Various authors have shown that e-learning methodology incurs lower costs when compared to in-person training<sup>(8,16)</sup>. In a study about basic vital support training via an online platform, an estimated 330 €/student<sup>(27)</sup> were saved.

Additionally, some authors affirm that the cost of contaminated BCs has been insufficiently researched, even though they can result in new extractions, increased hospital stays and the unnecessary use of antibiotics<sup>(28)</sup>. A study conducted in the United States estimated that this cost lies in 80,000 dollars, 4.5 additional days/patient, adding 5,000 more dollars to the final treatment. Reducing contaminated BC can have a significant effect on health costs as well as the suffering of patients and their families<sup>(5,29)</sup>. In the hospital investigated in the present study, the mean cost/day of a bed in the experimental group was 571.84 €/day and in the control group, 604.013€/day, with the additional money attributed to patients with contaminated BC, because longer hospital stays can incur significant costs. Thus, the "ethics of efficacy" must be adopted, based on adequate resource management<sup>(30)</sup>.

## CONCLUSION

The ECS online platform improved the knowledge relative to BC extraction technique among internal medicine nurses.

The educational intervention helped reduce BC contamination, reaching levels close to recommended quality standards.

Limitations of the study include the fact that the experimental group was compared to routine work training, and not to a traditional methodology. Furthermore, even though all the internal medicine nurses participated in the study, the number of participants was low. Thus, the methodology should be applied to other internal medicine units in other health centers.

## RESUMEN

**Objetivo:** Evaluar la eficacia de una plataforma formativa en línea de procedimientos en una planta de medicina interna para disminuir los hemocultivos contaminados. **Método:** Estudio cuasi-experimental con grupos paralelos. La muestra la componen enfermeras de medicina interna de un hospital terciario, con las que se lleva a cabo un programa de formación en línea en relación a la técnica extracción de hemocultivos. Se evalúan conocimientos pre y post intervención sobre la técnica. Además, se estudian los resultados de los hemocultivos 6 meses antes y 3 después de la intervención, analizando los contaminados. **Resultados:** Participan un total de 48 enfermeras. El conocimiento de la técnica antes de la intervención es homogéneo en ambos grupos, mejorando significativamente con la formación en línea ( $p=0.0001$ ). El análisis de hemocultivos extraídos previos a la formación muestran niveles de contaminación por encima del estándar internacional, disminuyendo en el grupo intervención hasta el 3% después del programa de aprendizaje. **Conclusión:** La intervención educativa mediante una plataforma digital se muestra válida para la adquisición de conocimientos y su translación a la práctica clínica.

## DESCRIPTORES

Cultivo de Sangre; Contaminación; Flebotomía; Enfermería; Educación en Salud.

**RESUMO**

**Objetivo:** Avaliar a eficácia de uma plataforma formativa on-line de procedimentos em uma unidade de medicina interna para diminuir as hemoculturas contaminadas. **Método:** Estudo quase-experimental com grupos paralelos. A amostra foi composta de enfermeiras de medicina interna de um hospital terciário, com as quais é realizado um programa de formação on-line com relação à técnica de extração de hemoculturas. São avaliados os conhecimentos pré e pós intervenção sobre a técnica. Além disso, são estudados os resultados das hemoculturas seis meses e três depois da intervenção, analisando os contaminados. **Resultados:** Participou um total de 48 enfermeiras. O conhecimento da técnica antes da intervenção é homogêneo em ambos os grupos, melhorando significativamente com a formação on-line ( $p=0.0001$ ). A análise de hemoculturas extraídas previamente à formação mostram níveis de contaminação acima do padrão internacional, diminuindo no grupo intervenção até 3% depois do programa de aprendizagem. **Conclusão:** A intervenção educacional a partir de uma plataforma digital se mostra válida para a aquisição de conhecimentos e sua transição à prática clínica.

**DESCRITORES**

Hemocultura; Contaminação; Flebotomia; Enfermagem; Educação em Saúde.

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