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RESEARCH ARTICLE

APPLYING THE KIRKPATRICK-MODEL ON EVALUATING AN EDUCATIONAL INTERVENTION ABOUT TRANSFUSION MEDICINE AMONG NURSES. PRELIMINARY RESULTS

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Abstract

Background: Implementation of systematic and sustainable training in theoretical and practical aspects of transfusion, maximizes transfusion-safety and improves quality of nursing services. Kirkpatrick-Model can be used effectively for evaluating such educational programs.

Method and Materials: According to Kirkpatrick-Model, evaluation of educational programs is determined by four levels: 1st-Reaction, 2nd-Learning, 3rd-Behavior, 4th-Results. During years 2018-2019, an educational program about transfusion-medicine (presentations-lectures, brochures distribution, individual training) was implemented among nurses working mainly in an Oncology Hospital of the Hellenic National Health System. Demographics, educational/professional experience, knowledge-level on transfusion-medicine as well as suggestions for improving it, were checked with pre-and post-training questionnaires. Statistical analysis was made using SAS9.4-software for Windows/Excel 2007 (Kruskal-Wallis method for numeric parameters, x^2-test for categorical). The significance level was set to $P<0.05$.

Results: Regarding trainees' reaction (level 1), 38.59% considered the educational program "satisfactory" (before training, 13.67% answered that they needed no training, after training 52.26%, $P<0.05$).

Regarding learning (level 2), there was improvement in knowledge (14.2±3 correct answers/respondent before training, 21.1±1.8 correct answers/respondent post-training, 48.6% increase in correct answers/respondent, $P<0.000001$).

The evaluation of the trainees' change of work-behavior due to training (level 3) will be performed through an extended observation-period by auditors using an extensive evidence-based observatory checklist. The overall outcome of training (level 4) will be assessed after completing the above-mentioned audits.

Conclusions: According to Kirkpatrick-Model, the applied educational program is evaluated positively in terms of levels 1-2, as it was considered sufficient by trainees and improved their theoretical knowledge. Further evaluation in terms of levels 3-4 is an ongoing procedure.

Keywords: Transfusion medicine, education, evaluation, Kirkpatrick Model, nurses.

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INTRODUCTION

Blood transfusion is a common clinical practice with excellent efficiency. Although gradual reduction in the frequency of transfusions which is observed over the last years[1-6] has resulted in elimination of various transfusion related errors/mistakes during any step from the donor's up to the patient's vein, (analysis of these incidents by Hemovigilance Systems shows that they mostly happen during bedside procedures (>60%).[7] According to these studies, a relatively small percentage of transfusion adverse reactions are unpredictable and therefore impossible to mitigate or avoid. In contrast, most incidents could probably be preventable by thorough, constant, and repetitive personnel training in both the laboratory and the clinical wards which can help in identifying threats, mitigating errors, and managing risks to strengthen transfusion safety.[8-14]

The presented pilot case study research evaluates an educational intervention, which was applied to improve the level of knowledge in Transfusion Medicine among nurses, by using Kirkpatrick's Model-elements.

METHODOLOGY

Kirkpatrick's Model (KM) is a useful tool for evaluating training programs, as it assesses their effectiveness at four levels:

(1) Trainee's response to the training experience (including training experience).

(2) Learner's learning outcomes and increase in knowledge, skill, and attitude towards the attendance experience (how much attendees learned the content after training). This level is usually measured through using a pre-test and post-test.

(3) Students' change in behavior and improvement (whether the learning transferred into practice in the workplace) and

(4) Results (the ultimate impact of training).[15]

Our study assesses the trainees' response to the educational program (level 1) and checks the improvement in their knowledge-level about Transfusion Medicine (TM) matters (level 2), taking into consideration factors such as their education level and working experience. Evaluation of the program by using levels 3 and 4 of KM is an ongoing procedure, and presentation of its results are not an objective of this paper.[16]

The study was conducted for two years (2018-2019) with participation of nurses working in clinical departments in an Oncology Hospital of Athens-Greece and postgraduate students at Nursing University working in other hospitals

The research consisted of three phases. In the first phase (phase A), a knowledge check about blood transfusion among the participants took place through a thematic pilot questionnaire. The questionnaire design included the participant's information sheet, the standard consent items, and the relevant pilot testing documentation. Thirty random participants were chosen to test the entire questionnaire (pilot run) for any comprehension-induced bias. The followed pilot testing process focused initially on the validity. The questionnaire included a set of control questions (non-sensical, unrelated or logical inversions of previous items) to identify speed-responders, automated response systems and participants selecting answers in random to preserve the validity of collected data and increase the reliability. Furthermore, the triangulation of input sources during the qualitative phase increased the credibility and trustworthiness. Finally, for the sake of increased analytical robustness, 95% bootstrapped Confidence Intervals (CI) selected as an additional confirmatory method to significance testing (both t-tests and B coefficients); as bootstrapping is resistant to most parametric assumptions' violation, such as normality and variance constancy. In the following period (phase B), statistical analysis (qualitative-quantitative) of the questionnaire's answers revealed through a thematic approach, the areas, and volume of interventions–education needed to be applied so as to enhance their knowledge and skills and clarify misunderstandings regarding TM matters. After completing the intervention-education, their level of knowledge was re-evaluated via an evidence-based questionnaire (phase C) to see if optimization was achieved through the intervention policy.

The aforementioned questionnaires (pre- and post-test, according to the second KM level) were paper-based and anonymous and consisted of two parts.

The first part included nine questions with details about:

- participants' demographics (age, sex),
- working experience (years of work, in general or university hospital),

- number of transfusions per day during the last six months and
- educational experience and needs (level of nursing education, previous education about TM, fields of TM-study they need to be retrained in).

Having gathered the nurses' answers to these questions, we evaluated their' response to the educational intervention by using the first level of KM. Focusing on the existing educational and working experience, we assessed the level of their knowledge about TM, and we identified gaps and training areas needed to be improved.

The second part of the questionnaire included 25 multiple-choice questions (four possible answers, one correct), divided into three sections, regarding as bellow:

- Transfusion-practice matters, e.g., patient identification before blood sampling or starting a blood transfusion, concurrent infusion of red blood cells and other fluids, acceptable duration of a transfusion, handing and disposal of blood components etc.
- Adverse reactions e.g., identifying an adverse reaction, first aid and monitoring etc.
- Other transfusion-related matters e.g., basic immunohematology principles, traceability, evaluation of the effectiveness of a transfusion, etc.

Answers to the second part's questions helped us to assess the nurses' initial knowledge and evaluate any positive impact of the educational intervention on its level (level 2 of KM). Additionally, these questions will be enhanced through a proposed observatory checklist for future evaluation of the participants' skills improvement, following the third level of KM (changing in behavior).

Nurses were invited to answer the aforementioned before and after implementation of selected-through thematic analysis literature review- intervention policy (phase B). This intervention policy consisted of transfusion-related educational activities such as lectures in the hospital and the university auditorium, small group sessions, one-to-one discussions, distribution of educational material (e.g., leaflets, posters) in the clinical wards and upload of all the educational material in the site of the hospital. Doctors, nurses, and health visitors of the hospital's Transfusion Service were responsible for all these activities, in cooperation with the hospital's Nursing Committee.

Electronic spreadsheet data forms (Excel 2016, Microsoft/Corp. WA, USA) and SAS software version 9.4 for Windows (SAS Institute Inc., NC, USA) were used for the statistical analysis. Arithmetic parameters were statistically analyzed by using the Kruscal-Wallis method. Categorical parameters were analyzed by using the X^2 test. For all tests, the significance level was set to $P<0.05$, and the confidence interval (CI) to 95%,[17] all tests were two sided.

The research protocol was approved by the hospital's Scientific Committee and follows its Ethics Committee's code. The permission to conduct the study was obtained from the Board of Directors and the Hospital's Scientific Committee. Participation was voluntary. All participants completed an informed consent form.

RESULTS

Two hundred and thirty-four (234) participants completed the questionnaire in phase A of the study, and 199 of them (85.04%) completed it in the repetitive phase (phase C). Most of them are women (82.48% & 82.41% in phases A and C respectively), working in Hospitals of the Greek National Health System (97.01% & 96.48%) as professional nurses (94.45% & 89.31%), while the rest of them (5.55% & 10.69%) are auxiliary nurses.

Data about the participants' demographics and their working and educational experience in phases A and C are depicted in Table 1.

A substantial improvement was observed regarding the number of correct answers in the initial and the repetitive questionnaire. More specifically, the number of correct answers before the intervention was on average of 14.2±3.0 per respondent (and respectively the rest: 10.8±3.0 were false), while after the intervention, we had 21.1±1.8 correct answers ($P<0.000001$). Practically a 48.6% increase in the percentage of correct an-

swers per respondent was observed. Focusing on each of the three sections of questions included in the questionnaires, we found that the aforementioned improvement concerned all investigated fields. The qualitative analysis of the intervention policy (focused on the distribution of correct and false answers per questionnaire-section) and the answers in the questions with the highest and the weakest improvement per sectio006Ew are depicted in Tables 2 and 3, respectively.

As for the correlation between the level of knowledge about transfusion and the educational level of nurses, data show that before the implementation of the educational activities, the number of correct answers depended on the level of education in a statistically significant level- more specifically, there was an upward trend from nurses graduated from technical schools (auxiliary nurses) to those graduated from university schools (P= 0.0022). Contrary to this, although the gradation remains after training, it has stopped being statistically significant (P= 0.1586) as showed in diagrams (a) and (b) in figure 1.

The above-mentioned results in terms of the KM second level (participants' learning outcomes) revealed a significant difference between the total scores before and after the intervention, not only in all the trainees but also in the subgroups regarding the level of the undergraduate education.

In contrast to the training level, the working experience does not verify to affect the number of correct answers. Before and after educational intervention, the degrees of correlation of the participants' performance with their working experience do not differ in a statistically significant level (CC before: -0.11, CC after 0.0451, P>0.05 in both cases).

Regarding the trainees' response to the educational program, as shown in Table 1, 13.67% of them, in phase A, stated that they did not have any need for training, while the corresponding percentage in phase C is 52.26%. That means that 38.59% of the participants characterize the phase B-training program as "adequate".

The impact of their undergraduate education level on their need for additional training, the education level seems to be related to this need, only after the intervention (phase C). In this phase, 80.95% of the Technical School graduates, 46.15% of the School of Applied Sciences graduates, and 34.29% of the University graduates stated that they would like to have extra education on TM (P=0.0025), while corresponding percentages before intervention were 92%, 88.41% and 75.56% (P=0.0576).

As for the years of working experience, this factor seems to be related to this need, neither before nor after the intervention (P=0.3384 & P=0.4318 before and after the intervention, respectively). Diagrams in figure 2 depict the above-mentioned correlations.

The aforementioned findings lead to the conclusion that, especially in the initial phase of our study, indiscriminately, all participants stated that they needed extra training. According to the KM first level, this need shows their positive predisposition towards the training program and is a prerequisite for its success and sustainability.

DISCUSSION

This study used KM elements to evaluate an educational intervention applied in nurses, in order to improve their knowledge in TM.

The KM was developed in the 1950s and analyzes and evaluates the results of training and educational programs. It is applicable in any style of training and determines its aptitude based on four levels criteria: Level 1 (reaction) measures how participants react to the training (e.g., are they satisfied?), level 2 (learning) analyses if they genuinely understood the training (e.g., increase in knowledge, skills or experience), level 3 (behaviour) looks at the utilization of what they learned at work (e.g., change in behaviours), and level 4 (results) determines if the material had a positive impact on the organization.

Using the first level of KM, we found that the trainees' response towards the implemented educational program was positive. The number of the participants (n=234) is considered adequate and includes mainly nurses from one of the biggest Oncology Hospitals in Greece as well as nurses working in other Hospitals of the city.[18] Similarly, the percentage of nurses who re-answered the questionnaire after the education activities

(phase C, n=199, 85.04%) is adequate, as there was no expectation for a 100% completion of the distributed questionnaires.[19] The number of participants denotes the need of the nurses to enforce their knowledge about TM. Their interest in the program was noticeable during the whole course (constant presence in the lectures, invitations for one-to-one discussion, study, and comments on the distributed educational material, etc.) and could be a prerequisite for its success. Almost 40% of them answered that they do not need extra training after phase B, which shows that the program met their needs, and it was satisfactory.

On the other hand, using the first level of KM we revealed knowledge gaps needed to be handled. This is proved by the relatively moderate level of correct answers in study-phase A, as well as the fact that 48% of participants declared that the intervention practices revealed and covered knowledge-gaps in TM. According to their answers to relevant questions, the knowledge gaps were connected with the lack of theoretical education in TM since they were students.

Nurses' training in TM is a matter of significant importance as nurses are involved in many steps of the transfusion chain from donor to recipient. In UK, legislation since 2006 suggests nurses' training in TM, Continuing Professional Development programs for staff in blood transfusion, regular documented transfusion training, and minimum two-yearly accreditation of nurses' competency.[20] Similarly, training programs concerning TM are applied in many other countries in order to improve nurses' knowledge and performance.[21-28]

In Greece, there are three levels of education in Nursing: Technical Schools, School of Applied Sciences, and University (2-, 3- and 4-years duration of the study, respectively). Even if blood transfusion is a procedure that concerns almost any nurse and any patient, none of the aforementioned educational organizations include TM-courses in their syllabus. Only nurses who work in Transfusion Services follow a six-months-training program before joining the Transfusion Service's staff. The rest of them attend only one or two relative lessons in the context of other undergraduate courses, and they practice training on the job after getting hired. Any training on TM during their professional life is among the duties of each hospital's TM Committee. The existence of these Committees was legislated in 2000, in order to promote blood safety by formulating transfusion therapy strategies in hospitals, and monitoring compliance with the rules of good practice. This is achieved through recording, analyzing, and evaluating the adverse events in the transfusion chain, and by training the staff of clinical departments in TM matters. However, these Committees underfunction in most Greek hospitals, as shown from the participants' answers.

Using the second level of KM, we found that the applied training intervention significantly improved all participants' knowledge level. A noticeable improvement was observed in all the subject areas of the questionnaire regardless of the level of their undergraduate education and the years of their working experience. The intervention policy was designed following evidence-based learning themes through a comprehensive literature review formatted in subject areas of the questionnaires and lectures.

The training program's evaluation by using the third level of KM includes the students' change in behavior and improvement (whether the learning transferred into practice in the workplace). Behavior change and possible improvement are planned to be monitored, recorded, and analyzed through an extended observation period with audits in the working environment. Trained auditors will check the change in the working behavior in specific and measurable subjects related to the intervention areas through an extensive evidence-based observatory checklist. Implementation of a workshop could also assess whether the learning was transformed into practice in the workplace. Furthermore, through Safety Management System records of each participating department of the hospital in the intervention project, safety reports could be used in the quantitative analysis of the third level of KM. This period is extended up to 2022 as limitations in human resources due to COVID pandemic affect the observation phase. The implemented program's ultimate impact (fourth Level of KM) will be revised af-

ter the completion of the observations.

The educational procedure used in this pilot case study research has local characteristics, as it took place in the context of the educational program of one hospital, and it was not applied on a broader scale (e.g., in the context of the syllabus of an educational organization). In order to achieve significant improvement in nurses' knowledge and performance in TM, further measures are required. Enriching the undergraduate education with TM-courses within the framework of the evidence-based educational program both on a theoretical basis and at the level of practical education is the one pillar of suggested interventions. As blood transfusion is one of the most common procedures in daily clinical practice and is potentially applicable to any patient, the transfusion therapy training process should be continued throughout the nurses' professional life.[29] Further activation of the TM Committee of each hospital could be the second pillar of continuous education, by applying relevant regularly conducted interventions to preserve their professional competency.

These interventions could include classical type lectures (in the hospital's auditorium, in the clinical ward), one-to-one education or e-learning courses with workshops and lectures.[30,31] The training should be repetitive and focused on enabling retention of theoretical knowledge and practice, and the provided information must be updated and following the "good practice-principles". The educational material should be attractive, practical, and easily accessible (e.g., a hard copy or/and an electronic folder with codified, illustrated transfusion-related procedures placed in the nurses' office in every clinical ward).[32] The education's effectiveness and efficiency could be audited and confirmed through both the reduction of the reported transfusion-related errors and mistakes and the stated satisfaction of patients and collaborators (related to the third phase of KM).[33] Additionally, nurses should be encouraged to express their training needs and their opinions about educational tools.[34,35] Accreditation of nurses' competency could be a quality indicator for both the clinical department and the hospital.[36-38]

Sustainability of such programs is a big challenge. To achieve this goal, intervention training policies must be specific, realistic, effective, and efficient, with accountability systems, to ensure their implementation. Their implementation must be entrusted to people with the right skills and attitudes, and their results must be monitored and measured. Affordability and flexibility should also be characteristics of such programs and supporting processes and structures must be institutionalized in the hospital. Most of all, they require a strong commitment from all the stakeholders: trainers, trainees, and administrative and financial authorities of each hospital.

In conclusion, in terms of the KM, the educational intervention was effective, as it addressed the actual problem (lack of knowledge in transfusion) in order to prevent re-occurrence and minimize its likelihood. It was also efficient, as it eliminated the problem in a cost-effective approach. Trainees embraced the program with their high participation level as a positive attitude towards it. The level of their knowledge in TM was significantly improved, regardless their educational or working background. Implementation of systematic, regular, and sustainable training in theoretical and practical aspects of transfusion, can maximize blood transfusion safety and improve the quality of the nursing services.

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ANNEX

TABLE 1. General characteristics of the study population.

	Before the implementation of educational activities (phase A)	**After the implementation of educational activities (phase C)**
Number of participants	234	199
Sex - Female - Male	 193 (82.48%) 41 (17.52%)	 164 (82.41%) 35 (17.59%)
Age	41.1±6.7 (25-58)	41.9±6.7 (26-58)
Education - University - School of Applied Sciences - Technical School	 17 (7.26%) 192 (82.05%) 25 (10.69%)	 13 (6.53%) 165 (82.91%) 21 (10.56%)
Working experience Years In general hospital In university hospital	 14.3±8 (0-36) 227 (97.01%) 7 (2.99%)	 15.3±8 (1-36.7) 193 (96.98%) 6 (3.02%)
Number of transfusions/day during the last six months	2.8±1.2 (0-5)	3±1.2 (0-6)
Previous education about blood transfusion	9 (3.85%)	160 (80.4%)
Fields of transfusion medicine need to be retrained in: - taking blood-sample - administrating a blood transfusion -managing adverse reactions - no need for training	 14 (5.98%) 92 (39.31%) 181 (77.35%) 32 (13.67%)	 0 16 (8.04%) 89 (44.72%) 104 (52.26%)

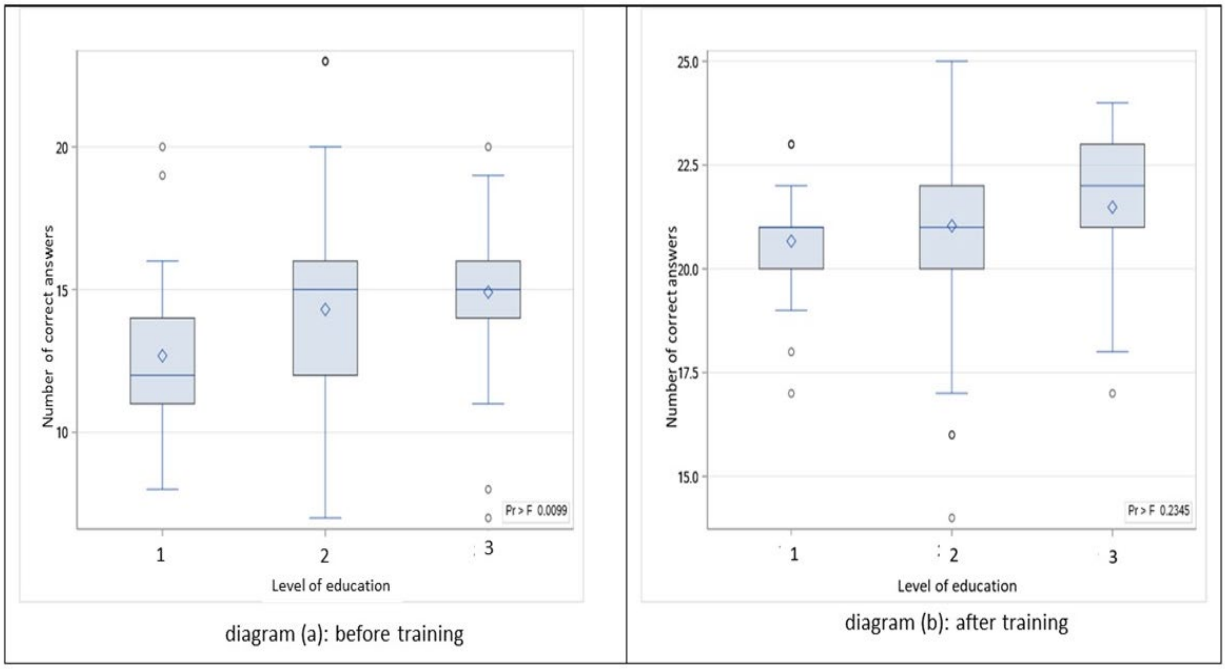
TABLE 2. Qualitative analysis of intervention educational policy– Answers distribution.

Questionnaire- section	**Before the implementation of educational activities (phase A, 234 participants)**		**After the implementation of educational activities (phase C, 199 participants)**		
	Correct answers **Mean value ± SD (min-max)**	**False answers** **Mean value ± SD (min-max)**	**Correct answers** **Mean value ± SD (min-max)**	**False answers** **Mean value ± SD (min-max)**	**P-value**
Section a (15 questions regarding transfusion-practice matters)	9.3±2.2 (2-14)	5.6±2.2 (1-13)	12.8±1.2 (9-15)	2.2±1.2 (0-6)	<0.00001
Section b (5 questions regarding adverse reactions	2.3±1 (0-5)	2.7±1 (0-5)	4±1 (1-5)	1±0.8 (0-4)	<0.00001
Section c (5 questions regarding other transfusion-related matters	2.6±1 (0-5)	2.3±1 (0-5)	4.3±0.7 (2-5)	0.7±0.7 (0-3)	<0.00001
Total	14.2±3 (7-23)	10.8±3 (2-18)	21.1±1.8 (14-25)	3.9±1.8 (0-11)	<0.00001

TABLE 3. Topics with the highest and the weakest improvement per section.

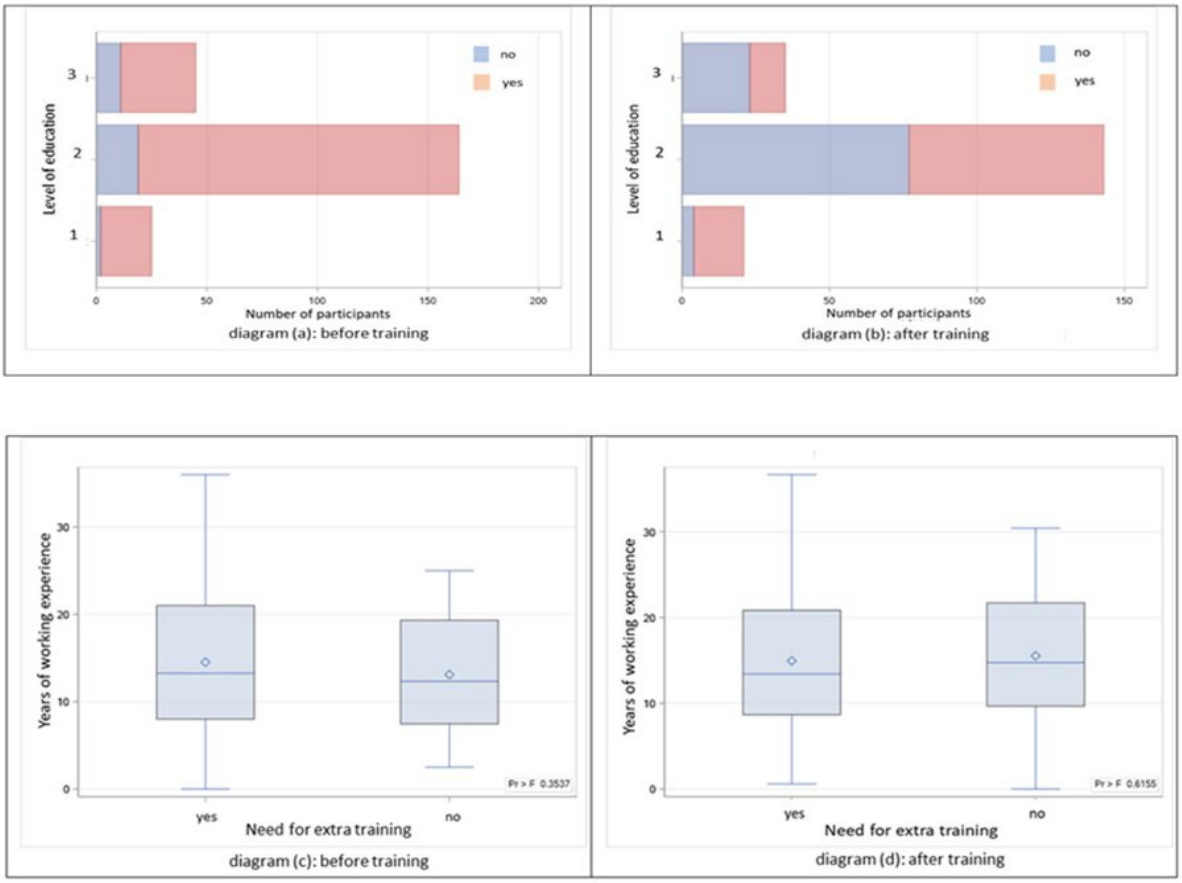
Topic	**% Correct answers before vs. after the implementation of educational activities**	**Odd-Ratio**	**P-value**
Section a (15 questions regarding transfusion-practice matters)			
- Only one blood unit at a time must be delivered in the clinical ward.	94% vs 99.5%	12.6 (1.6-96.7)	0.001
- The duration of an RBC unit-transfusion must not exceed 4 hours	28.75% vs 76.26%	8 (5.2-12.3)	<0.0001
- An RBC unit must be transfused through a 170—240 microns filter	39.03% vs 58.46%	2.2 (1.5-3.2)	<0.0001
Section b (5 questions regarding adverse reactions)			
- As soon as an adverse reaction is observed during a blood transfusion, the transfusion must stop immediately, and both the identity of the patient and blood unit must be re-checked	12.02% vs 75.37%	22.4 (13.5-37.3)	<0.0001
- A rapid onset of 39°C fever, accompanied with rigor, pulse rate 120bpm, and hypotension, is due to the acute septic reaction	14.16% vs 67.34%	12.5 (7.8-20)	<0.0001
- An onset of tachypnoea, tachycardia, coughing, sudden anxiety, and jugular vein distension in an aged patient which is transfused with 2 RBC units is due to TACO	79.06% vs 87.94%	1.9 (1.1-3.3)	0.0139
Section c (5 questions regarding other transfusion-related matters			
- FFP units of the AB group can be transfused to patients of any ABO group	6.83% vs 72.36%	35.7 (19.7 -64.7)	<0.0001
- Every blood donation in Greece is tested for HBV, HCV, HIV, HTLV, syphilis	39.31% vs 83.92%	8.1 (5.1-12.8)	<0.0001
-If an already crossmatched RBC unit has not been transfused to the patient in less than 72h after crossmatching, it must be re-crossmatched	48.65% vs 80.40%	4.3 (2.8-6.7)	<0.0001

FIGURE 1. Before training, the number of correct answers responds to nurses' education-level. After training nurses improved their knowledge, and the gradation in correct answers regarding their education-level becomes statistically insignificant.



Abbreviations: Education-level 1=Technical School, 2=School of Applied Sciences, 3=University

FIGURE 2. Participants' statement for additional training, accordingly to their educational level (diagrams a and b) and their working experience (diagrams c and d).



Abbreviations: Education-level 1=Technical School, 2= School of Applied Sciences, 3= University