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THE EFFECTS OF EDUCATION AND TRAINING GIVEN TO PHLEBOTOMISTS FOR REDUCING PREANALYTICAL ERRORS

ZNAČAJ EDUKACIJE I OBUKE FLEBOTOMISTA ZA UMANJENJE GREŠAKA U PREANALITIČKOJ FAZI

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Summary

Background: The most common sources of error in the preanalytical phase are considered to be at the stage of patient preparation and sample collection. In order to reduce the preanalytical errors, we aimed to determine the level of phlebotomists knowledge about the preanalytic phase before and after planned trainings in the study.
Methods: Training about preanalytical processes was given to the 454 health professionals and the majority of them were employed as nurse. Questionnaires before and after training were conducted. In order to assess the effect of the training into the process, preanalytical error rates were calculated before and after training.
Results: The total correct answer rates of vocational school of health diplomaed were statistically lower than the total correct answer rates of other. It was observed significantly increase in the rate of correct answers to questionnaire and significantly decrease in preanalytical error rates after training.
Conclusions: The results of the survey showed that the attitudes of the phlebotomists were diverse in the preanalytical processes according to the levels of education and their practices. By providing training to all staff on a regular basis, their information about preanalytical phase could be updated and hence, it may possible to significantly reduce the preanalytical errors in health practice and nursing science.

Keywords: preanalytical error, education, training, phlebotomy

Kratak sadržaj

Uvod: Najčešći izvor grešaka u preanalitičkoj fazi jeste u pripremi pacijenta i uzimanju uzorka. U nameri da se umanje preanalitičke greške, cilj ovog rada je bio da se utvrdi nivo znanja flebotomista pre i posle planirane obuke istih.
Metode: Obuka o preanalitičkom procesu obuhvatila je 454 zdrava profesionalca od kojih su većina bile zaposlene sestre. Sprovedeno je ispitivanje putem upitnika pre i nakon obuke. Kako bi se procenio uspeh obuke izračunat je nivo preanalitičkih grešaka pre i posle obuke.
Rezultati: Ukupan broj tačnih odgovora bio je statistički manji kod školovanih zdravstvenih radnika u odnosu na ukupan broj ostalih. Takođe je uočeno značajno povećanje tačnih odgovora u upitniku i značajno smanjenje preanalitičkih grešaka nakon obuke.
Zaključak: Rezultati ovih ispitivanja ukazuju da greške u preanalitičkoj fazi značajno zavise od nivoa obrazovanja flebotomista. Obezbeđivanjem obuke ukupnom laboratorijskom osoblju je od velikog značaja u svakodnevnom radu, kao i poznavanje svih informacija o preanalitičkoj fazi, što značajno umanjuje broj mogućih grešaka u zdravstvenoj službi.

Ključne reči: preanalitička greška, edukacija, obuka, flebotomija

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Introduction

Preanalytical phase comprises of test request, patient preparation, obtaining of the sample from the patient, transportation of the sample to the laboratory, and preliminary sample handling for analytical processes. Preanalytical errors still account for about 60–70% of laboratory-based errors. About one-fifth of preanalytical errors might have been the cause of inappropriate clinical decisions, treatments, redundant advanced tests and economic losses (1). In the past decades, a 10-fold reduction in the analytical error rate has been achieved thanks to improvements in both reliability and standardization of analytical techniques, reagents, and instrumentation. Notable advances in information technology and quality control procedures have also assured a valuable contribution for reducing diagnostic errors. Thus, nowadays errors in the preanalytical processes are more prominent (2).

It is accepted that the most common sources of error in the preanalytical phase are in the steps of patient preparation and sampling (3). For this reason, most of the quality and standardization efforts related to training focused on »phlebotomists«. In addition, the role of nurses in the organization of preanalytical processes is great such as the transfer of samples to the laboratory and its organization. According to the study made in 28 European countries, 5–11% of phlebotomy processes are conducted by expert phlebotomists, 10–32% are by laboratory technicians, and 45–65% still by nurses. In general, most of these individuals basic education is 4–5 years of high school, followed by 2–5 years of colleague or university, and there is no standardization in their training. In addition, about in one third of them there is not any specific educational program or a continuous training opportunity for phlebotomy (4). Thus, these new graduates, who come out on the field with the lack of training, practically trained by other senior phlebotomists during implementation, which may lead to the transfer of inadequate or even faulty information and almost might have been the cause of entrenched errors. For this reason, it may be necessary to provide regular phlebotomy training for both new graduates and for senior healthcare professionals in the period of before and after graduation while striving for reducing the preanalytical errors in the laboratory.

Although there are standard procedures for the collection of diagnostic blood specimens by venipuncture issued by Clinical and Laboratory Standards Institute (H3-A6 standard) (5) and World Health Organization (WHO) Guidelines on Drawing Blood (6), they are not very applicable for everyday health care services because of being so comprehensive and extensive. Therefore, it is recommended to establish national guidelines to adapt to local cultural and institutional orientation (considering the language, legislation, moral values, the curriculum and the duration of the training of the operators, their basic education, etc.) by taking advantage of international phlebotomy guidelines (4). For adapting to this recommendation, a guidebook for Venous Blood Collection (Phlebotomy) has been prepared by »Preanalytic Phase Working Group of Turkish Biochemistry Association« (7).

International Organization for Standardization (ISO) document 15189:2012 standard is focusing especially on phlebotomy by inclusion the preanalytic processes in to accreditation (8). According to this ISO standard, medical laboratories are account for providing educational instructions and training opportunity to the staff related with preanalytic phase. According to Turkish Ministry of Health, National Health Quality Standards-version 5, provision of quality in the preanalytical processes is the responsibility of all health professionals involved in the process together with the requester clinicians as well as the laboratory professionals. The supervision of each phase of these processes and the training of the relevant personnel are emphasized and included in the criteria.

In our study, we aimed to designate the knowledge level of the phlebotomy personnel related with preanalytical phase before and after training in order to reduce the preanalytical errors. In addition, the effect of the training on preanalytical errors in practice has been studied.

Methods

In March 2016, a training on preanalytical processes has provided to 424 health personnel, including 100 pediatric nurses and 281 adult nurses and 43 laboratory technicians, which constitute approximately half of the employees performing phlebotomy in University of Health Sciences, Tepecik Education and Research Hospital, Izmir, Turkey. Two hours of training was theoretically and visually performed by a biochemistry specialist plus an authorized employee who works as a local representative of Becton Dickinson company. The protocol for the study was reviewed and approved by the University of Health Sciences, Tepecik Education and Research Hospital's Management. Participation in the study was on the basis of informed consent and the study was carried out in compliance with the Helsinki Declaration.

Before and after training, questionnaires, consisting of 17 questions which include demographic characteristic and preanalytic phase stages, have been conducted to the relevant personnel (n=324). The contents of the program for the training of pediatric nurses were not the same in terms of blood sampling techniques, sampling sites or blood sampling tubes in usage. To create a focused group in the evaluation process, adult phlebotomists were

Table I The original questionnaire form applied to participants.

Questionnaire for Training Related to Preanalytical Processes	
Name-Surname: Date:	
1. Level of education: Vocational school of health Associate degree (2 years) Bachelor's degree (4 years) 2. Age: 3. Years of experience working as a health professional: 4. Did you have any previous knowledge of the preanalytic process? Yes, I am aware of that Yes, I heard but not clear. No, I am not aware of that 5. Have you been educated before about the preanalytical error? Yes No 6. Which stage does the preanalytic process not cover? The identification of patient The blood sampling and sample transfer to the laboratory Analyzing sample and reporting the results 7. What percentage of incorrect results are due to the preanalytical process? 7% 10% 30% 70% 8. Which disinfectant should be used before collecting blood (except for ethanol analysis)? Alcohol (70%) Betadine / Baticon Dry cotton 9. Is it possible to palpate after disinfection? Yes No 10. How long the tourniquet should be kept? 15 seconds 30 seconds 1 minute 2 minutes	11. Which of the following is not a preanalytical error? Hemolyzed sample Sample with clot Inadequate or excess sampling Sample identification error Sampling to the incorrect tube Incorrect reporting 12. Which test is not affected by hemolysis? CK / CK-MB AST Potassium Glucose LDH 13. Please make the order of the tubes mentioned below? Blood culture bottle ( ) Coagulation tube (blue cap) ( ) Hemogram tube (lavender cap) ( ) Biochemistry tube (yellow/red cap) ( ) 14. Which of the following tube/tubes are turned upside-down? Biochemistry tube Hemogram tube Sedimentation tube Coagulation tube All 15. In which tubes should not the clotting occur? Hemogram tube Sedimentation tube Coagulation tube All 16. How long the blood samples taken for biochemistry tests should be delivered to the laboratory at the latest? 30 minutes 1 hour 2 hours 3 hours 17. What are the most common error sources that you were informed?

chosen, and hence pediatric nurses were not asked to fill the questionnaires. The questionnaire filling rate was 93.2% (n=302). Questions 1–5 were descriptive type, 6–16 were closed type questions (multiple-choice questions with only one possible answer) and 17th was open-ended type. The original questionnaire form was shown at *Table I*.

In order to assess the effect of the training on the preanalytical process, preanalytical error rates one month (February 2016) before and one month (April 2016) after training have been calculated by using (number of rejected samples/total numbers of samples × 100) formula. The data for these calculations were obtained from the local »Hospital Information System« (HIS). Before and after training, sample rejection

criteria were classified as: deficient or extensive and mistaken test requests, unsuitable blood sampling (blood sampling from an extremity given any treatment, inappropriate disinfectant use, prolonged tourniquet application etc.), inadequate or excess sampling, sample with clot, hemolyzed sample, sampling to the incorrect tube, sample identification error, patient identification error, and sample transfer errors (late transferring to laboratory or non-arrival).

For statistical analyses, Statistical Package for the Social Sciences (SPSS) 20.0 program (SPSS Inc., USA) has been used. The difference between age and average working year of participants according to the graduate degrees (vocational school of health diplomaed, associate degree, bachelor's degree) were determined by using one-way ANOVA. Then, it was followed up with a Post Hoc test according to variance homogeneity. The differences between the participants' correct answer before training according to the graduate degrees was evaluated by Chi-Square test. Additionally, the difference of correct answers before and after training was compared with McNemar's test. The difference between the preanalytic error rates for February and April was evaluated by the test for the significance of a difference between two proportions or percentages. A value of $p < 0.05$ was considered as statistically significant.

Results

The employees who participated in the survey were between the ages of 17–61 with a mean age of 34.0±9.6 years. Fifty of these personnel (16.5%) were graduated from vocational school of health school, 54 (17.9%) had associate degree, and 198 (65.6%) had bachelor's degree. The average working year of the personnel was 12.1±9.5 years. Forty of them were employed in emergency service, 74 were in intensive care, 11 were in the blood-sampling unit, 43 were in laboratory, and 134 were in other services.

The descriptive characteristics of the participants according to their level of education were given in *Table II*. The vocational school of health graduates were the youngest group in terms of age and their professional experience was lower than the associate degree and bachelor's degree. The age and working year of either associate degree or bachelor's degree personnel were higher than those of vocational school of health graduates. When it comes to the level of education, the ranking according to professional experience was as follows: associate degree, bachelor degree, vocational school of health diplomaed. Not any significant difference could have been found between the groups having different academic levels ($p=0.111$ and $p=0.557$, respectively) in responses to questionnaire about whether they have pre-information or any pre-training about preanalytical processes. It was observed that the preanalytical awareness and education rates were low in health employees with different levels of education. Although, there was no statistical difference seen preanalytical awareness and education rates in bachelors' degree, both were higher in this group in which gave rise to the thought that the higher the level of education, the higher the awareness of the preanalytical process. Before training, the total correct answer rates of vocational school of health diplomaed were seen as 51.2%, for associate degree it was 60.9% and for bachelor's degree found as 60.6%. Statistically, by comparison with other groups' rates, the rates of vocational school of health diplomaed found significantly lower. Also, while the correct answer rate of laboratory technicians was 68.5%, the service nurses' and in blood taking unit staff' rate was 57.6% and there was a significant difference between them ($p < 0.001$).

On the question-based evaluation, the correct response rates of vocational school of health graduates were found statistically significant lower than those of associate degree and bachelor degree only in 9^{th} (disinfection related) and 13^{th} (blood sampling order to tubes related) questions. For the other questions, no significant difference was detected according to the level of education. Besides the answers given to the 17^{th} question were mostly such as: inadequate sampling, sample with clot, hemolyzed sample, sample identification error, and sampling to the incorrect tube, it was observed that the problems they met most frequently could be different according to their level of education.

The percentage of correct answers before and after the training was shown in *Table III*. The percentage of total correct answers in the questionnaire was 59.1% before training and 92.2% after training have showed a statistically significant increase ($p<0.001$). Not any significant change rate has been detected only in 9^{th} question related with disinfection during blood sampling at question based analysis. A significant increase has been seen in the correct response rates of all other questions. It was found that the training had a positive effect by increasing the knowledge about the errors in preanalytical phase.

In order to detect how the knowledge increased by training was reflected in daily practice, the causes of error for rejection in preanalytic phase before one month (in February) and after one month(in April) training have been evaluated and presented in *Table III*. Preanalytical error rates were 0.60% before training (in February) and 0.50% after training (in April) which showed a statistically significant decrease ($p < 0.001$). Cause of error with the highest sample rejection rate was determined as »deficient or extensive and mistaken test requests«. Especially, the »deficient or extensive and mistaken test requests« and »unsuitable blood sampling« errors significantly decreased after training (*Table IV*).

Table II Descriptive characteristics of participants according to their degree of education and correct answer percentages.

Question Number	Questions and correct answers	Vocational school of health	Associate degree	Bachelor's degree	P value
1	Level of education:	50 (16.5%)	54 (17.9%)	198 (65.6%)	–
2	Age (years)	26.1±8.5	37.8±8.8	34.9±9.0	<0.001
3	Years of experience working as a health professional	6.7±7.4	17.1±8.8	12.2±9.5	<0.001
4	Did you have any previous knowledge of the preanalytic process? Correct answer: Yes, I am aware of that	7 (14.0%)	8 (14.8%)	53 (26.8%)	0.111
5	Have you been educated before about the preanalytical error? Correct answer: Yes	7 (14.0%)	11 (20.4%)	41 (20.7%)	0.557
6	Which stage does the preanalytic process not cover? Correct answer: Analyzing sample and reporting the results	32 (64.0%)	40 (74.1%)	153 (77.3%)	0.157
7	What percentage of incorrect results are due to the preanalytical process? Correct answer: 70%	17 (34.0%)	20 (37.0%)	94 (47.5%)	0.133
8	Which disinfectant should be used before collecting blood (except for ethanol analysis)? Correct answer: Alcohol (70%)	40 (80.0%)	44 (81.5%)	165 (83.3%)	0.840
9	Is it possible to palpate after disinfection? Correct answer: No	43 (86.0%)	54 (100.0%)	194 (98.0%)	0.000
10	How long the tourniquet should be kept? Correct answer: 1 minute	13 (26.0%)	24 (44.4%)	77 (38.9%)	0.130
11	Which of the following is not a preanalytical error? Correct answer: Incorrect reporting	41 (82.0%)	43 (79.6%)	174 (87.9%)	0.236
12	Which test is not affected by hemolysis? Correct answer: Glucose	18 (36.0%)	24 (44.4%)	90 (45.5%)	0.481
13	Please make the order of the tubes mentioned below: Correct answer: Blood culture bottle (1) Coagulation tube (blue cap) (2) Hemogram tube (lavender cap) (4) Biochemistry tube (yellow/red cap) (3)	5 (10%)	18 (33.3%)	44 (22.2%)	0.017
14	Which of the following tube/tubes are turned upside-down? Correct answer: All	24 (48.0%)	35 (64.8%)	107 (54.0%)	0.205
15	In which tubes should not the clotting occur? Correct answer: All	35 (70.0%)	42 (77.8%)	164 (82.8%)	0.120
16	How long the blood samples taken for biochemistry tests should be delivered to the laboratory at the latest? Correct answer: 1 hour	12(24.0%)	18 (33.3%)	58 (29.3%)	0.576
17	What are the most common error sources that you were informed?	- Inadequate sampling - Sample with clot - Hemolyzed sample - Sample identification error - Sampling to the incorrect tube	- Inadequate sampling - Sample with clot - Sample identification error - Hemolyzed sample - Sampling to the incorrect tube	- Sample with clot - Hemolyzed sample - Inadequate sampling - Sample identification error - Sampling to the incorrect tube	
	Total correct answer	280 (51.0%)	362 (61.0%)	1320 (61.0%)	<0.001

Table III The correct answers and percentages before and after training.

Question Number	Questions and correct answers	Before training, n (%)	After training, n (%)	p value
6	Which stage does the preanalytic process not cover? Correct answer: Analyzing sample and reporting the results	225 (74.5%)	285 (94.4%)	<0.001
7	What percentage of incorrect results are due to the preanalytical process? Correct answer: 70%	131 (43.4%)	268 (88.7%)	<0.001
8	Which disinfectant should be used before collecting blood (except for ethanol analysis)? Correct answer: Alcohol (70%)	249 (82.5%)	287 (95.0%)	<0.001
9	Is it possible to palpate after disinfection? Correct answer: No	291 (96.4%)	297 (98.3%)	0.210
10	How long the tourniquet should be kept? Correct answer: 1 minute	114 (37.7%)	293 (97.0%)	<0.001
11	Which of the following is not a preanalytical error? Correct answer: Incorrect reporting	258 (85.4%)	291 (96.4%)	<0.001
12	Which test is not affected by hemolysis? Correct answer: Glucose	132 (43.7%)	230 (76.2%)	<0.001
13	Please make the correct order of the tubes mentioned below: Correct answer: Blood culture bottle (1) Coagulation tube (blue cap) (2) Hemogram tube (lavender cap) (4) Biochemistry tube (yellow/red cap) (3)	67 (22.2%)	268 (88.7%)	<0.001
14	Which of the following tube/tubes are turned upside-down? Answer: All	166 (55.5%)	296 (98.0%)	<0.001
15	In which tubes should not the clotting occur? Correct answer: All	241 (79.8%)	291 (96.4%)	<0.001
16	How long the blood samples taken for biochemistry tests should be delivered to the laboratory at the latest? Correct answer: 1 hour	88 (29.1%)	254 (84.1%)	<0.001
	Total correct answer	1962 (59.1%)	3060 (92.1%)	<0.001

Table IV Reasons for rejection and total preanalytical error rates of samples one month (February 2016) before and one month (April 2016) after training. Data were taken from local HIS.

Cause for rejection	February		April		p value
	n	%	n	%	
Deficient or extensive and mistaken test requests	236	33.4	159	28.4	<0.05
Unsuitable blood sampling	226	32.0	107	19.1	<0.05
Inadequate or excess sampling	97	13.7	106	19.0	>0.05
Sample with clot	58	8.2	58	10.4	>0.05
Hemolyzed sample	31	4.4	45	8.1	>0.05
Sampling to the incorrect tube	20	2.8	38	6.8	<0.05
Sample identification error	16	2.3	10	1.8	>0.05
Patient identification error	11	1.6	19	3.4	>0.05
Sample transfer error	11	1.6	17	3.0	>0.05
Preanalytical error rate (Number of rejected samples/total numbers of samples × 100)	0.60 (709/118008)*100		0.50 (559/111418)*100		<0.05

Discussion

We have evaluated the educational position, working experiences and the knowledge level about the preanalytical processes of the phlebotomists with the help of our questionnaire study. In addition, we investigated the effect of the training on the preanalytical error rates of employees according to their graduation degrees and background information, and therefore the contribution of education to the professional practice. Because of no standardization in their graduation degrees and not going through the same training process throughout their education, the knowledge about the preanalytical processes differed from each other. Especially, this difference was manifested itself by the low rate of correct answers for vocational school of health graduates whose duration of education was minimum. Moreover, both age and professional experience of these graduates were lower than other phlebotomists. However, the total correct answers of individuals who had associate degree were being equal to the participants with bachelor degree; hence, this can be explained by the fact that although they had less graduate level the associates professional experience were higher than the bachelors. In this case, it shows that not only the level of education, but also the experience gained in daily health practice can positively affect the knowledge on preanalytical processes.

When we compared the knowledge levels of laboratory technicians and service nurses, it was determined that the knowledge levels of laboratory technicians were superior. Indeed, other survey studies on venous blood collection also reported that laboratory technicians have better practice than clinic staff do. Besides, researches conducted on the clinic staff indicate that training was not associated with venous blood collection practice (10–12).

In our questionnaire, especially the vocational school of health graduates inexperience at basic rules about tube ordering during blood sampling and disinfection were drawing attention. Albeit, it may be expected that the approach to the preanalytic process will be more inexperienced in the group of the vocational school of health, because of the lower age and years of experience. For this reason, the importance of tube order during blood sampling and the rules of disinfection can be highlighted and reviewing of relevant training curriculum and hands on training in a more memorable way can be ensured. Although the vocational school of health group's correct response rate related with the question about disinfection did not change after training ($p=0.180$ for correct response rate from 86% to 100%), there was a significant increase in knowledge about tube order during blood sampling ($p<0.001$ for correct response rate from 10% to 80%).

The correct response rate of the survey participants for the tourniquet application time was 37.7% in the study. The correct answer rate to this question did not change according to the level of education. In literature, there are other studies with low percentage (45.5%) as in our study (13). Serdar et al. (14) also found that the tourniquet application time did not depend on the experience of the staff. While the correct answer rates (55.5%) for the question related with turning upside-down of tubes were similar to the rates of the study (44.1%) performed by Yüksel et al. (13), the difference between the correct answer amounts to the question related with the tube transportation time to laboratory was drawing attention (respectively, 29.1% and 91.0%).

Positive results were obtained by the training given after graduation to raise awareness for preanalytical errors. The total correct answer rate with our training increased by 56.0%. Only in disinfection question, the rate of correct answers were high at beginning and after the training did not change. This situation gives rise to the thought that the reason for having been the highest correct response rate to this question originate from why it is taught as a grand rule in the basic health education and daily practice of health.

A significant decrease in monthly preanalytical error rates was observed after the training. In the study performed by Ozcan et al. (15), in-service training about blood sampling was provided to all clinic nurses and to the blood sampling staff by the training committee on the first day of May, July, and October. There was a statistically significant decrease in rejected percentages in the months training given, but an increase observed again in the next months. The reason for that could be the frequency of in-service training is inadequate and the risk of making mistakes during the sampling of the newcomer until the next training is high.

It has been emphasized that the training program for nurses is important in reducing the errors and in quality improving (16). It is also noted that applications such as the use of labeling systems will reduce the preanalytical errors (missing blood sample in particular). Thus, it may be possible to improve the preanalytical quality by identification, detection, and monitoring of errors. Quality indicators (IQs) defined by Sciacovelli et al. (17) and Plebani et al. (18) are designed to cover all steps of the pre-analytical phase. IQs play an important role in the realization of targeted continuous improvement activities to reduce errors in clinical practice. However, since IQs do not automatically result in quality improvement, we need to reach a consensus on preparation, adoption, and monitoring of standard procedures in the pre-analytical phase (19). Standardizations to be made should also include training programs and strategies.

When we classified the monthly preanalytical errors, the »errors in test request« and »unsuitable blood sampling« were found to have the highest rate of errors. After the training, a significant enhancement observed in the rates of these two errors, but no improvement/decrease seen in other ones. In the study performed by Aksit et al. (20) in our hospital, it has been reported that the most common cause of preanalytical errors was the test request errors and the training of medical secretaries could solve this problem. The main reasons for 'test request errors' which was found to have been the most reject rate in our study were observed such as: the codes of the parameters used in our hospital's emergency laboratory had diversity, test requests coming from services and intensive care units during out of working hours were being putting in process by the secretaries working in emergency services, appointment of medical secretaries in emergency laboratories who were employed in different departments, who were newly employed or who did not have a HIS training. Although some studies (21–23) have shown that the most common error source is a mistake in the test request, most of the other studies (24–28) indicate that they originate from hemolyzed samples. It is clear that education affects positively not only the level of knowledge, but also professional practice. Interestingly, there was an increase observed in the rate of »sampling to the incorrect tube« after training. As a limitation, due to the nature of the HIS system we used, the occupation of this group and their level of education could not identified further. Perhaps the new training is likely to create a confusion in the participants' perceptions. For this reason, it is planned to repeat this training to the same group by including a new training topic, which specifically intends to reduce this error.

Conclusions

By providing appropriate standardization of the preanalytic process through suitable, effective, and regular training: (i) preanalytical error rates can be reduced, (ii) avoidance of misdiagnosis and malpractice can be achieved, (iii) compliance with service quality standards can be ensured, (iv) patient and employee safety can be increased, (v) labor and economic losses can be avoided, (vi) prolonged »turnaround time« due to redundant sample or test repetitions can be shortened. In order to reach all these goals, the training process must be decisive, sustainable, and standardized and should repeat at appropriate intervals. The training process should internalized by creating an internal audit system with the participation of the trainers and the supportive attitude of the management. Knowledge about appropriate sampling and preanalytical process can updated by providing training to the beginners before starting to practice and regularly repeating trainings for the senior staff who continue to practice. In this way, labor and economic losses due to preanalytical errors can be prevented and results that are more accurate can be obtained in a short period.

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Conflict of interest statement

The authors stated that they have no conflicts of interest regarding the publication of this article.

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