

# Developing Educational Content about the Preanalytical Phase of the Total Testing Process for Non-laboratory Healthcare Personnel

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Educational content is essential for shaping and advancing knowledge on, and improving the quality of, the preanalytical phase of the total testing process for biological samples. Process steps occurring after the preanalytical phase are also impacted by educational content about this phase. This literature review includes studies on education and training that focus on blood collection performed by non-laboratory healthcare staff. The aim is to suggest developments for educational content on sample collection occurring outside the laboratory to facilitate learning and improve the quality of the preanalytical phase of the total testing process when performed by non-laboratory healthcare staff. The 39 articles included in this review were published from 2010 to 2016, and were identified from an initial literature search of electronic databases conducted in 2015, and a second additional search conducted at the end of 2016 using keywords and certain selection criteria. The articles were categorized into three groups according to the suggestions for educational content for training non-laboratory staff about the preanalytical phase of the total testing process. Each of three categories represented an approach to the content that could influence knowledge development and the quality of the training. The findings of this review provide new and unconventional perspectives that may be used to further develop educational content for, and the knowledge of, non-laboratory healthcare professionals regarding biological sample collection. The findings also contribute to reduced field errors by non-laboratory healthcare professionals during the preanalytical phase of the total testing process.

*Key words: literature review, preanalytical, blood sample collection, education, multi-professional*

## Introduction

Today, various healthcare professionals collect and handle biological samples outside of the laboratory. These professionals are key as they are responsible for the representativeness of the samples and the reliability of the laboratory results and patient safety [1]. Recently, interest in healthcare quality improvement and patient safety activities has increased, and laboratories are being asked to widen their scope of activities to include activities typically outside their purview [2].

The preanalytical phase of the laboratory total testing process has received much attention because errors continue to occur during this phase despite considerable efforts to reduce them. Since the early 1950s, scientists have warned that laboratory tests are not always foolproof [3-4]. Today, laboratory process steps and the factors affecting them are well-known [5-9], but less is known about how to prevent the effects of negative factors using staff education and training.

Most laboratory errors result from the preanalytical phase, e.g. inappropriate test requests, order entry, patient/specimen misidentification, sample collection, inappropriate containers, handling, storage, and

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Received: May 21, 2017 Revised: July 11, 2017 Accepted: March 27, 2018

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transportation. Therefore, knowledge of and proper training on the intervening factors are essential for reducing errors and optimizing operational quality. Laboratory errors can lead to repeated sampling, delayed diagnoses, patient suffering and, as a result, jeopardized patient safety [5, 8-9].

Blood samples should be collected according to national and international recommendations and standards [10]. This may seem a very simple issue, but the involvement of non-laboratory healthcare staff often creates interactions that seldom meet the standards and recommendations. Improving the quality of blood sampling practices begins only when healthcare staff are aware of the various factors that affect blood sample collection and the effects of these factors on good nursing care [1,11-14]. Therefore, nurses and other non-laboratory healthcare staff need more training in blood sample collection and other laboratory interventions.

Previous authors have demonstrated that groups of non-laboratory healthcare professionals have a very poor grasp of blood sampling standards and requirements and of the factors that affect blood sample quality. Since, many healthcare professionals have insufficient preanalytical skills [13,15-18], ensuring high quality biological sample acquisition by multi-professional healthcare groups is important [19-20]. Usability and safety of patient samples must also be guaranteed.

Training and education is a potential solution for reducing mistakes and improving the quality of biological sample collection by non-laboratory healthcare professionals. The training should promote awareness of the sampling standards and recommendations, and encourage commitment to compliance with them. It should also develop theoretical knowledge and practical skills that contribute to a culture that emphasizes patient safety. Designing such training and educational content for non-laboratory healthcare staff is challenging. However, designs of and approaches to blood sampling training must be given special attention, particularly for professionals involved with the nursing practice. Blood sampling is a fundamental aspect of training for non-laboratory healthcare professionals, and improving this training would increase knowledge and improve patient safety and the quality of the total testing process of biological samples.

This literature review describes the contents of existing blood sampling education and training for

non-laboratory healthcare staff. The aim of this review was to find suggestions for facilitating learning and improving the quality of the preanalytical phase of the total testing process for biological samples via education. We focused on educational and training content to further develop the knowledge and quality of the preanalytical phase of the total testing process. We hope that this review provides new perspectives for educators. Our findings may be used for planning preventive and corrective measures for blood sampling conducted outside the laboratory to reduce the incidence of errors.

## **Materials and methods**

We chose a literature review as the method for identifying suggestions and views on the topic of interest using existing data. This method allowed us to extract various aspects of educational content from the field of laboratory specialists' work that should be included in education and training for non-laboratory healthcare staff to improve their knowledge about the preanalytical phase of the total testing process for biological samples.

A library information specialist searched the EBSCO Cumulative Index of Nursing and Allied Health Literature (CINAHL), EBSCO PubMed and SAGE Journals databases, and the search yielded 622 articles. These articles were subjected to initial screening for the following criteria. Only original, peer-reviewed articles published in English between 2010 and 2015 that addressed blood sampling, the preanalytical phase, education, multi-professionalism, and quality were included for literature review. Table 1 presents the search terms used. After initial screening, articles that did not meet the inclusion criteria were excluded. The remaining articles (N=61) were read again, and articles that did not meet the criteria were excluded. Both researchers read and discussed the relevant articles identified from the search. After removing the duplicates, 55 studies remained.

In November 2016, an additional search was conducted using the same conditions described above. This search yielded 13 more studies. All the newly-found articles were read and discussed. After a final screening, all the additional studies were included. In the end, 39 original research articles were included in this literature review.

**Table 1 Databases, search terms, and dates of searches**

Database	Search terms
EBSCO CINAHL	"preanalytic", "blood sample" OR "blood sampling" OR "venipuncture", "training" OR "education"
EBSCO PubMed	"preanalytic", "education", "multi-professional", "blood sampling" and "quality"
EBSCO CINAHL	"preanalytic", "clinical", "training"
SAGE Journal	"preanalytic", "blood sample", "blood sampling", "training" OR "education"

## Quality appraisal

One limitation of this literature review limitation is that the articles about laboratory work and training made very few slight references to learning and educational content. Many articles did not mention learning in depth or lacked the rationale behind content choice. Most contained no direct reference to learning or the learning cap. Another limitation is the small sample size. The subject of this review is a scarcely-explored area on which only a few studies have been conducted. The articles selected had only brief descriptions or short statements (a sentence or two) on learning. Furthermore, the articles we reviewed contained little theoretical basis for learning or teaching. A critical assessment of the literature was conducted, and the selected articles provided information about, and suggestions for, educational content regarding the preanalytical phase of the total testing process for blood sampling. The data analysis methods were suitable for describing educational content, and this contributes to the reliability of this review.

The review was designed to focus on blood sample collection and to produce information on educational content about the preanalytical phase of the total testing process. The aim of the review was to highlight the importance of education, for non-laboratory healthcare staff, for facilitating learning and thus reducing errors occurring during the preanalytical phase. The findings of

the review must be interpreted in the specific context of its limitations. Despite these limitations, the direction, strength and consistency of the review findings indicate the outcomes are robust.

The review met the criteria for reliability and validity. Both researchers have extensive knowledge of the review topics, are highly experienced in the subjects, and are thoroughly acquainted with all the articles included in the review. Classification and data analysis were conducted step-by-step.

## Data abstraction and synthesis

The research articles were organized into three major groups based on their training-related content to synthesize the data from the articles (Table 2). Group 1 addressed inter-departmental communication and co-operation and highlighted multifaceted approaches to content and their significance for the quality of training and education (multi-professional co-operation). Group 2 included articles related to errors and quality indicators as valuable tools for assessing and monitoring practices, and to the significance of errors to the content and quality of education (learning from mistakes). Group 3 included articles related to standards, checklists, and directly-related factors, and their significance for qualified learning and education (recognizability of guidelines).

**Table 2 Original studies classified**

Classification of Category	References
Multi-professional co-operation	Loh & Sethi (2015), Romero et al. (2009), Wallin et al. (2010), Kumar et al. (2014), Lippi et al. (2008), Makhumula- Nkhoma et al. (2015), Therrell et al. (2010), Lippi & Simundic (2010), Lippi & Guidi (2007), Cadamuro et al. (2016), Dikmen et al (2015), Sanchis-Gomar & Lippi (2014), Lippi et al. (2015), Atay et al (2014)
Learning from mistakes	Söderberg et al. (2009), Agarwal et al. (2012), Koseoglu et al. (2011), Dorotić et al. (2015), Lima-Oliveira et al. (2012), Lillo et al. (2012), Ying et al. (2014), Dikmen et al. (2015), Abdollahi et al. (2014), Guidi & Lippi (2008), Cuhadar et al. (2013), De Carli et al. (2014),
Recognizability of guidelines	Seemann & Nybo (2016), Damato & Rickard (2015), Bölenius et al. (2013), Wallin et al. (2007), Lima-Oliveira et al. (2013) MLO: (2005), Lippi et al. (2013), Lippi et al. (2015), Llopis et al. (2016), Garcia et al. (2015), Yin et al. (2015), Simundic et al (2013),

## RESULTS

### Multi-professional co-operation

This category focused on multi-professional education and training contents and activities. Several of the studies review highlighted the importance of cooperation among the various healthcare professions and continuous training for improving the quality of the preanalytical phase of the total testing process [21,23]. Some studies justified this importance by stating that the world is changing rapidly, so healthcare professionals must continually communicate with one another to achieve the training objectives. Another justification from these studies was that laboratory education must meet current healthcare needs [24-25]. The studies suggested that many non-laboratory healthcare professionals need to be aware of the impact of the preanalytical phase of the total testing process on patient outcomes [16]. Non-laboratory professionals should understand their role within the entire healthcare system to grasp this impact [26], and should look at procedures while considering the total testing process in the context of the greater healthcare system [27]. Some studies highlighted the practice of asking the patient preparing for the test about potentially influential variables [28]. Several reviews revealed that quality management of the total testing process requires multidisciplinary co-operation between all professional healthcare groups involved [28]. Implementation of the strategy requires full commitment and co-operation between departments [29].

### Learning from mistakes

This category focused on errors and quality indicators and associated educational approaches and interventions. Many studies reported that use of quality indicators (clotting, hemolysis, suitable test requests, etc.) could efficiently facilitate learning and improve education [30-32]. For example, one study suggested the use of Lean-Six Sigma tools for pinpointing factors such as hemolysis as key inefficiencies in blood collection and the preanalytical workflow [33]. Quality indicators were considered extremely valuable tools for maintaining quality control systematically and transparently [20,34-37]. Lillo et al. [38] stated that most sampling errors are made by non-laboratory healthcare

personnel. Therefore, the educational program for nursing personnel is important for reducing sampling errors, raising awareness about preanalytical phase errors, and improving the quality of learning. Inclusion of medical topics in assessments of education and training for laboratory medicine is essential for evaluating nurses' awareness of preanalytical testing variables. After additional training, the changes in respondents' behavior generally and towards others was noteworthy [39]. Preanalytical phase errors are largely made by non-laboratory healthcare staff who are not overseen by a clinical laboratory. Most of these errors can be prevented by organizing efficient training for other personnel besides phlebotomists [31].

Learning from mistakes can be evaluated with large-scale educational intervention programs (EIP) for primary healthcare phlebotomists. More than half of laboratory errors are related to the preanalytical phase of the total testing process. EIPs would improve phlebotomists' practical performance by providing time for reflections and discussion. A modular organizational structure in healthcare facilities would allow for directed educational interventions based on specific guidelines on flaws present at a specific unit [40]. Therefore, proper training and knowledge of the intervening factors are essential for reducing errors during and optimizing the quality of the preanalytical phase [41]. Undergraduate education and teaching in laboratory medicine should highlight specific tasks related to laboratory competencies and skills that are required for optimizing the learning capabilities of the students [42]. Several studies emphasize the importance of using quality indicators and proper documentation during the laboratory process [26,34,43].

### Recognizability of guidelines

This category focused on guidelines and approaches to educational content aimed at reducing errors occurring during the preanalytical phase of the total testing process. Some studies suggested that international guidelines should be followed locally by professionals that collect biological samples in healthcare systems in all European countries [42,44-46]. Patient-centered care could positively influence patient safety and increase safety during the preanalytical phase of the total testing process if it includes standardized routines and regular staff training [47-48]. Performing sampling procedure steps in an incorrect order could reduce patient safety. Therefore, Lima-Oliveira et al.

[15] stated that the effects of preanalytical interferences must be accounted for in every modern clinical laboratory.

Some studies suggest that training on the preanalytical phase of the total testing process should meet certain certification and licensing requirements [49-50]. Over recent decades, significant improvements to reliability and standardization of the process caused a tenfold reduction in analytical errors. For example, Lippi et al. [51] stated that most errors in laboratory diagnostics still occur in the pre- and postanalytical steps, outside of the analytical phase. In turn, a study by Seeman [30] demonstrated that the conditions for phlebotomy (hand hygiene, the order of draw, improper mixing of samples) are not always ideal. Therefore, adherence to the Clinical & Laboratory Standards Institute (CLSI) guidelines H3-A6 should be recommended for other professionals besides phlebotomists who collect biological samples. None of the most frequent errors, listed in parentheses above, were in the red zone. An error in the red zone occurs during the patient identification process, which is crucial according to the CLSI H3-A6 guideline. Lippi et al. [53] identified reasons why knowledge of the recommendations and standards is scarce. This lack of knowledge leads directly to hazardous behaviors by healthcare professionals and might explain why these professionals ignore important safety rules.

Quality management of the preanalytical phase of the total testing process requires consideration of the overall healthcare context. Assuring the quality and safety of the total testing process requires management initiatives to improve the testing process and to harmonize the procedures. Error reduction was notable when standardized procedures for the preanalytical phase were implemented in Spain [54]. Best practices should be optimized for the collection, handling, and management of blood culture specimens. Improper blood culture collection also increases financial burden [15]. Yin, Lehmann, & Xu [56] stated that preanalytical phase risks and errors are more common than expected, even when standard operating procedures (SOP) are used.

## Discussion

This literature review was conducted to find suggestions for developing educational content for training non-laboratory healthcare professionals to facilitate their learning and improve the quality of the

preanalytical phase of the total testing process.

The findings of this review indicate that developing educational content about the preanalytical phase of the total testing process for non-laboratory staff is possible. Such content has been examined to a lesser degree from the perspective of non-laboratory healthcare professionals; this review presents some new perspectives on the content of training on the preanalytical phase for these professionals. Training on the preanalytical phase of the total testing process should be promoted to reduce errors that occur during this phase.

Typically, articles in the laboratory field focus mainly on laboratory process steps and the factors affecting them, and place less emphasis on actual educational content and its implications for the knowledge of non-laboratory healthcare professionals. Facilitating learning about the preanalytical phase of blood sampling is a key factor when the aim is to increase commitment to the quality of the total testing process by non-laboratory healthcare staff.

This literature review led to the formulation of three categories and explicitly defines their significance for development of educational content on the pre-analytical phase of the total testing process. Thus, this review presents new perspectives on content and provides educators with tools for training non-laboratory healthcare professionals that can be implemented in various healthcare contexts. The tools could improve commitment and motivation of non-laboratory healthcare staff to perform blood sampling in a standardized manner, thus reducing mistakes and improving the quality of the preanalytical phase.

According to Dorotic et al. [36], more than 70% of nurses are eager to improve their knowledge of the preanalytical phase of the total testing process. These nurses considered additional training about preanalytical factors useful. Educators should ensure that training on the preanalytical phase of the total testing process meets requirements for effective learning and accounts for the essential factors of high quality testing processes.

This literature review identified the most common features of educational content for blood sample collection and the preanalytical phase of the total testing process. These features were associated with improving the knowledge of non-laboratory healthcare professionals: multi-professional co-operation, learning from mistakes, and recognizability of guidelines. Our findings indicate that increasing knowledge of and commitment to standards is the most important goal of the training. The educational content must be based on

requirements for certification and licensing, and must be relevant to the healthcare context.

Error prevention is a major goal in healthcare environments where many different healthcare professionals work together. An appreciation for multi-professional cooperation by healthcare managers enables a healthy understanding of functional roles in the preanalytical phase and facilitates better integration for the total testing process. Multi-professional cooperation requires discussion of different viewpoints which leads to transfer and development of knowledge.

Learning from mistakes is significant for improving the quality of the sampling procedure. In practice, identifying future errors and methods for handling them, and correcting errors immediately, are effective ways of learning, improving routines, and preventing error recurrence in the future. Moreover, supplementary or case examples of errors used in training should be relevant to practical work situations, and the impact of these errors on the reliability of the results should be assessed, thus improving the quality of the nursing care provided. The occurrence of sampling errors should not be over-emphasized, but an awareness of these errors can help professionals evaluate their behaviors and activities and, at best, can change their attitudes regarding their own sampling activities. Increased awareness of mistakes will also help professionals to identify them in practice and encourage them to further develop their skills. Regular updates of data related to the training are a good starting point for responsible operations and for correction of errors identified.

Healthcare professionals should adhere to the following: obligation to collect samples using a standard procedure, guarantee of proper operation of practical nursing, standardization of the conditions, and fulfilment of the quality requirements regardless of time and the client. Adherence to these standards demonstrates recognizability of guidelines by healthcare professionals.

The value of this study is that it reveals various new perspectives about educational content on the preanalytical phase of the total testing process, combines the results of several studies on such content, and draws attention to this content for blood sampling conducted by non-laboratory professionals. The results of many papers in the field of laboratory testing have been integrated, in this study, to provide a better understanding of the various aspects associated with the preanalytical phase of the total testing process. This literature review collates the views and thoughts of laboratory specialists on these aspects.

This review was conducted under different frames

of reference for specific learning needs; all the frames of reference had the common goal of facilitating learning. The review contributes improvements to educational content on the preanalytical phase of the total testing process in the field of laboratory work, which is not frequently studied, especially from the trainee's perspective. Thus, this review opens the subject for discussion and further research is needed. Texts from selected articles were used as the research material for this review, and the authors attempted to be as honest and careful as possible in describing the texts to interpret them correctly.

The three categories identified from this review reveal varied perspectives and provide a framework for approaching local on-the-job education and increasing learning. This review provides useful, practical information for designing training for non-laboratory healthcare professionals that reduces error and facilitates learning about the preanalytical phase of the total testing process. This review also enhances our understanding of education and training on blood sampling for non-laboratory staff. The findings should be used to improve the quality of education and training, thus facilitating learning, increasing commitment of non-laboratory staff to relevant standards and guidelines, and reducing blood sampling errors.

## Conclusions

This study describes various contents of education and training on the preanalytical phase of the total testing process. It also reveals significant perspectives regarding the quality of learning, and commitment to standards relevant to the total testing process, by non-laboratory healthcare professionals. If the knowledge of non-laboratory healthcare professionals about the preanalytical phase is to improve, the contents of education and training for them must be well-designed and must emphasize the significance of this phase.

We believe that regular training of non-laboratory healthcare professionals combined with certification and licensing of these professionals by the relevant educator could reduce errors occurring during the preanalytical phase, leading to increased patient safety and higher blood sampling quality. Communication between educators and healthcare providers must improve to ensure that training meets the needs of non-laboratory staff. Accounting for each individual's impact on specimen collection is critical for increasing blood

sampling quality, patient safety, and the reliability of laboratory results.

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