Emergency Department Nurses' Perceptions of Point-of-Care Testing in the Scope of Testing Process: A Qualitative Study

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Key Words: *Point-of-Care testing, nurse, patient safety, laboratory testing process, emergency nursing, qualitative study.*

Summary. *The aim of this qualitative study was to describe emergency department nurses' perceptions about Point-of-Care testing before and after the implementation of Point-of-Care testing at the nurse-managed practice.*

Design. This qualitative study was conducted in collaboration with one of the five emergency departments at a Finnish university hospital and the adjoining laboratory center.

Methods. The study was conducted in four stages: 1) a semi-structured pre-interview in three focus groups; 2) education in small groups; 3) a test period when Point-of-Care tests and instruments were independently used by nurses; 4) a semi-structured post-interview in three focus groups. All seven participants were interviewed twice. The deductive-inductive content analysis was used. Perceptions were considered and coded according to the testing process framework. The Point-of-Care testing process includes the pre-preanalytical, preanalytical, analytical, post-analytical and post-post-analytical phases. Each separate phase includes different actors that can hamper patient safety.

Results. The deductive-inductive content analysis revealed that patient identification during the preanalytical phase was error-prone even after data entry was automated. Perceptions towards quality assurance in the analytical phases were either positive or negative. An instrument's ease of use, independently performing the analysis of quality control samples, success in sample collection and proper examination of a patient's clinical status were shown to increase nurses' trust in the Point-of-Care test results.

Principal conclusions. It seems indisputable that Point-of-Care tests will soon be an integral part of nurses' work descriptions. Information about the frequency of various error types is insufficient if problems exist around Point-of-Care testing following adequate education and support from laboratory staff.

Introduction

Over the last decade, the market for Point-of-Care testing has continuously grown by more than ten percent in both Europe and the United States (1, 2). Several factors underlie this increased demand for Point-of-Care testing, notably, advances in computer technology along with smaller, portable, and easier to use instruments (3). The most commonly used Point-of-Care tests are blood glucose measurements, urinalysis and pregnancy tests (4). Point-of-care testing can improve clinical outcomes within the care pathway through faster clinical decisions and enable the implementation of a patient-centered approach (5, 6). The advantages of Point-of-Care testing include low sample volume, less invasive sample collection, as well as elimination of time-consuming sample transport and sample preparation (7). However, certain researchers cite excessive costs, extra work and a lack of understanding concerning the importance of quality control and assurance as disadvantages of this approach (8).

Point-of-Care testing can take place in various locations at a hospital, such as the doctor's office, emergency department, or intensive care unit, although self-testing, which is performed by laypersons, is also a growing segment (1). In the hospital setting, Point-of-Care testing is most likely undertaken by non-laboratory staff, for example, nurses, whose primary task is delivering patient care rather than analyzing laboratory samples (9, 10). Therefore, both adequate training of the staff performing Point-of-Care testing and support from the central laboratory are essential to ensuring safe patient management (6, 8, 10). Research has shown that Point-of-Care testing can improve patient outcomes by expediting patient care in terms of shorter hospital stays and timely discharge from emergency departments (6). The aim of this qualitative study is to describe emergency department nurses' perceptions of Point-of-Care testing before and after the

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implementation of Point-of-Care testing at a nurse-managed practice. Nurse-managed practice guides nurses to handle patients without having a necessity to see a physician.

Background

Point-of-Care testing (POCT) refers to the performing of laboratory tests near a patient (2, 8, 11). There are numerous definitions for Point-of-Care testing, and Ehrmeyer & Laessing (12) provide a definition which emphasizes that the rapid utilization of test results is one of the objectives of Point-of-Care testing:

"Patient specimens assayed at or near the patient with the assumption that test results will be available instantly or in very short timeframe to assist caregivers with immediate diagnosis and/or clinical intervention" (p. 766).

In addition, the fact that Point-of-Care testing happens outside of the laboratory and involves non-laboratory staff is common in most of the myriad definitions, as Jacobs et al. (13) brings out:

"Clinical laboratory testing conducted close to the site of patient care, typically by clinical personnel whose primary training is not in the clinical laboratory sciences or by patients (self-testing). POCT refers to any testing performed outside of the traditional, core or central laboratory" (p. vii).

In this study, Point-of-Care testing is considered in the scope of both previously mentioned definitions. In this way, the definition employed within this paper emphasizes rapid results from tests performed near the patient by non-laboratory personnel outside of the traditional hospital laboratory.

The total testing process is the framework through which laboratory professionals assess the possibility of errors related to laboratory tests. Traditionally, the total testing process is divided into three phases: preanalytical phase, analytical phase and post-analytical phase (14–16). In this study, the laboratory testing process is divided into five phases – pre-preanalytical, preanalytical, analytical, post-analytical, and post-post-analytical – and is referred to as the Point-of-Care testing process (17) (Fig. 1). The pre-preanalytical phase of the Point-of-Care testing process includes a clinician's decision to order a test (17, 18). The preanalytical phase consists of actions such as ordering the necessary test, patient identification, sample collection, sample handling, and sample evaluation. The analytical phase includes method calibration, reaction of sample and reagent(s), result generation, and quality assurance. During the post-analytical phase, the test result is interpreted and documented (15). The Point-of-Care testing process ends at the post-post-analytical phase with an appropriate action based on test result interpretation (17, 18). It is important to note that this clinical decision-making may put the patient at risk if the Point-of-Care test result is erroneous. Therefore, the training provided to nonlaboratory personnel must consider all aspects of Point-of-Care testing (19). Nevertheless, even if adequate training has been provided, there still exists the possibility that the busy clinical environment will cause faults or violations to the performance of Point-of-Care tests and instruments (10).

Methods

Study Design and Settings

This qualitative study was conducted in collaboration with one of the five emergency departments at a Finnish university hospital and the adjoining laboratory center. This emergency department has an annual patient flow of about 70,000. To improve patient flow and reduce "unnecessary" physician's visits, the emergency department was reorganized in 2010 (Fig. 2). This included the establishment of a nurse-managed practice, which handles an annual volume of approximately 11,000 non-urgent patients. Briefly, the nurse performing the registration and triage redirects a patient to a physician or to a nurse-managed practice based on the severity of the patient's signs and symptoms. Point-of-Care testing was later implemented to improve the patient flow and efficiency.

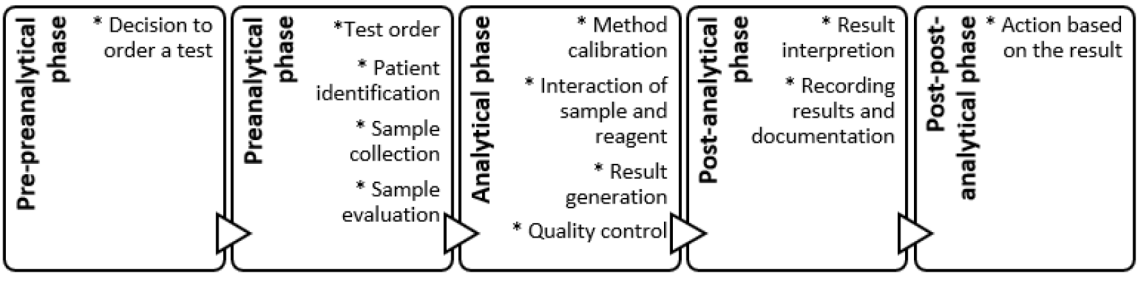

Fig. 1. Point-of-Care testing process

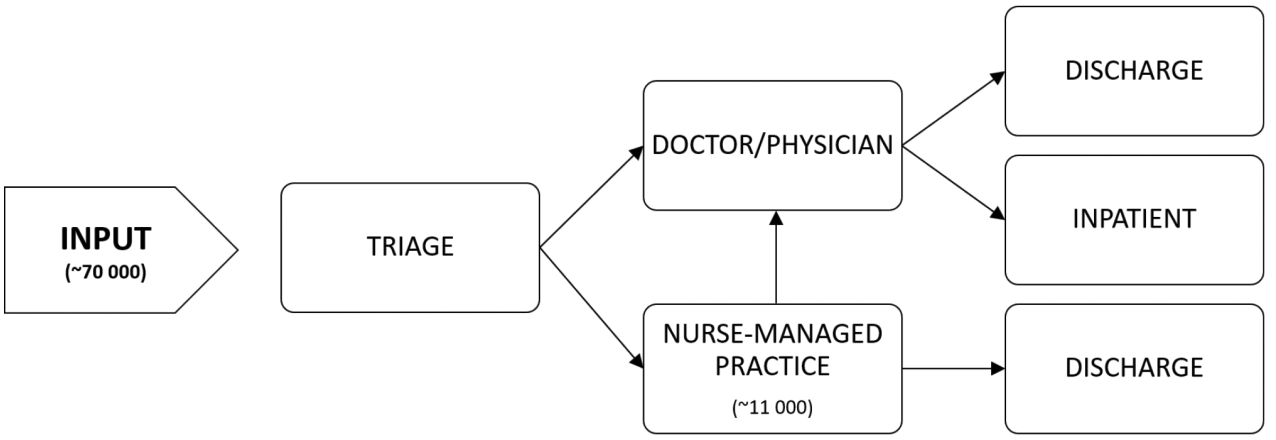

Fig. 2. Simplified illustration of the studied emergency department's patient flow after a nurse-managed practice was established in 2010

The study took place during autumn 2016. The study was conducted in four stages: 1) a pre-interview in focus groups; 2) education in small groups; 3) test period when Point-of-Care tests and instruments were used independently by emergency nurses; and 4) a post-interview in focus groups (Fig. 2). The education was conducted by laboratory staff in small groups of two to five registered nurses with a duration of two hours. After the education, the nurse-managed practice was reorganized so that nurses could perform Point-of-Care testing directly at their work stations without the involvement of laboratory personnel. Normally, nurses depend on the laboratory personnel for collecting and analyzing blood samples. The introduced Point-of-Care testing included tests and instruments for urinalysis, group A Streptococcus and c-reactive protein. A total of six focus groups were formed, with nurses participating in the study before and after the eight-week long test period. Even though nurses independently used Point-of-Care tests and instruments during the eight weeks, support from the laboratory's Point-of-Care unit was available when needed. As the timeframe between education and the start of the test period varied between the groups, the emergency nurses gathered three days before the start of the eight-week test period and discussed the most important issues relating to the use of Point-of-Care tests and instruments with the staff from the Point-of-Care unit. One of the paper's authors works in the Point-of-Care unit and was also present at this meeting.

Participants

Of the 78 nurses employed in the emergency department, 24 nurses working in the nurse-managed practice were educated on using Point-of-Care tests and instruments. Of these 24 nurses, seven emergency department nurses agreed to interviews before and after the test period. The nurses were purposefully recruited (20) in collaboration with the head nurse of the department. The inclusion criteria for participation in the study were proper qualification and specialization for working at an emergency department's nurse-managed practice. All the participants had graduated as registered nurses between 1994 and 2002, were women and had 5 to 17 years of experience working at an emergency department.

Data Collection

Semi-structured focus group interviews were conducted before and after the test period. Interviews were moderated by one researcher (KK), who is competent in the field of Point-of-Care testing. All seven participants were interviewed twice. There were three focus group interviews before the test period and three focus group interviews after the test period. The interview lasted between one and one and a half hours. A semi-structured interview guide, which was based on the Point-of-Care testing process theoretical framework, was used during the interviews (Fig. 1). The theoretical framework drew upon existing literature related to the care process at the emergency department (21) and the overall Point-of-Care testing process (15, 17, 22, 23), and was also influenced by the researchers' clinical experiences. Focus groups were used to obtain qualitative data about emergency department nurses' perceptions and experiences of Point-of-Care testing (20, 24). Employing focus groups allowed participants to share multiple perspectives and provided rich data as group members were stimulated by each other's responses to the discussed topic. The par-

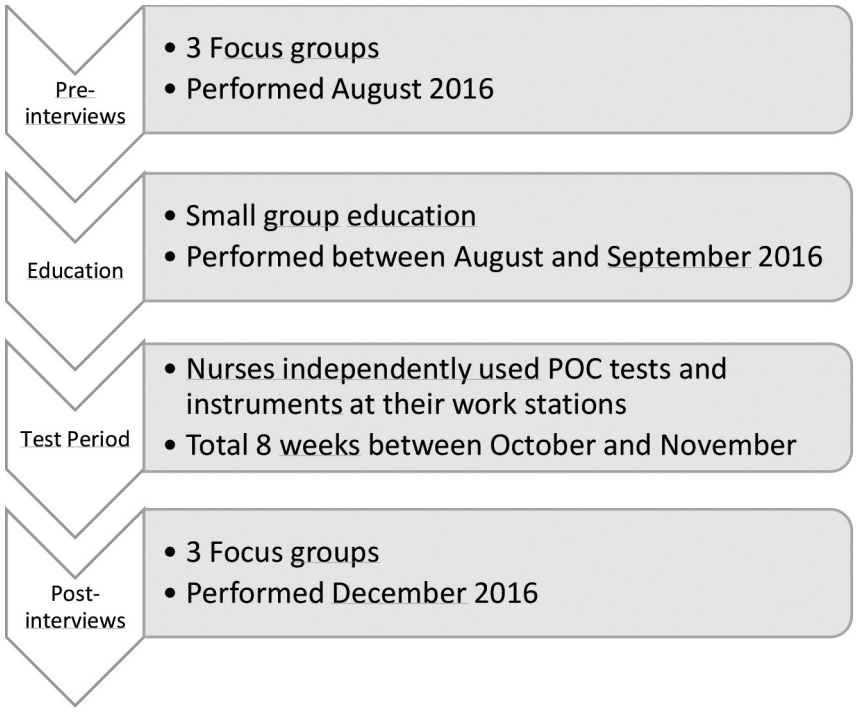

Fig. 3. Timeline for data collection

ticipants were persuaded that their opinions and experiences were important; therefore, no answers that were within the context of the discussed topic could be considered inappropriate (24). The interviews were recorded by using mobile application "Voice Recorder" (version 2.0.11) on an Android operating system.

Data Analysis

The deductive-inductive content analysis was used for data analysis. The interviews were transcribed verbatim, de-identified and coded by the same researcher. Only manifest content was analyzed. The response analysis was conducted in two phases and employed deductive-inductive content analysis in both the before- and after-test periods. The researchers read through all the written material several times to become completely familiar with the collected data and to obtain a sense of the whole (25, 26).

In the deductive phase of analysis, the data were coded according to Point-of-Care testing process themes (15, 17, 22, 23) and categorized based on content (26). The deductive themes were *Pre-preanalytical phase*, *Preanalytical phase*, *Analytical phase, Post-analytical phase and Post-post-analytical phase*. As the Point-of-Care testing process themes were selected deliberately, it is important to understand Point-of-Care testing as a whole phenomenon rather than a single performance (15, 17, 22, 23). After the data were distributed among the main deductive themes, the data in each deductive theme were then inductively analyzed. The data were split into meaningful units, coded, and then sorted under sub-categories based on differences and/or similarities. Sub-categories were gathered into broader categories, and similar categories were grouped under the appropriate main themes (25, 26). Data saturation was reached after all of the interviews had been analyzed (27).

Ethical issues

Research permission was obtained from the university hospital. According to the Finnish Medical Research Act (488/1999; 295/2004; 794/2010) (28), it was not necessary to obtain ethical committee approval since no physical and/or mental harm could arise during the research. The participants were invited by an informative email (27), and written informed consent was obtained from each participant prior to every interview (29). The participants were guaranteed confidentiality and the possibility to withdraw at any point throughout the study process. The focus group interviews were performed in a safe, nonthreatening, nondistracting environment in which the discussion was permissive and nonthreatening (20, 27).

Results

Emergency department nurses' perceptions of Point-of-Care testing before and after the utilization of Point-of Care testing in an emergency department's nurse-managed practice are presented according to the five distinct themes of the Point-of-Care testing process: *Pre-preanalytical phase; Pre-analytical phase*; *Analytical phase; Post-analytical phase; and Post-post-analytical phase* (Table 1).

Pre-preanalytical phase

The pre-preanalytical phase, which preceded the test period, was described by the category *Excessive laboratory test orders*, which included sub-categories

Table 1. Nurses' Perceptions Before and After the Utilization of Point-of-Care Testing

	Sub-Category	Category
Theme	**Pre-preanalytical phase**	
B	Problematic patients' need assessment Test orders in advance	Excessive laboratory test orders
A	Appropriate tests Deliberate use of instruments	Supported patients need assessment
Theme	Preanalytical phase	
B	Defective identification Untapped potential of wristband	Risky heterogeneity in identification
B+A	Issues in fingerpick sampling Typical in urine sample Notable in throat swab	Specific knowledge essential
A	Use of barcodes for identification Manual identification Errors in identification	Risky heterogeneity in identification
Theme	**Analytical phase**	
B	Possibility for errors minimized Basic knowledge	Baseline in quality assurance
B+A	Added workload Unpleasant task Laboratory's task Task of Point-of-Care testing operator	Ignorance of quality assurance Responsible party
A	Functional Point-of-Care testing instrument Confidence of the operator Special detailed knowledge	Patient safety responsibility of quality assurance
Theme	**Post-analytical phase**	
B	Clinical condition of patient Unexpected test results	Overall picture
B+A	Responsibility for documentation Documentation as deposit for performed tests Inadequate documentation found problematic	Patient safety attitude of documentation
A	Disregard of documentation Manual documentation is error-prone Preferred automated documentation	IT-solutions for ensuring documentation
	Doubts on interpreting Confidence on interpreting	Complexity of test result interpretation
Theme	**Post-post-analytical phase**	
B+A	Discharge Doctor's Practice	Test results as action
B, Before test period A, After test period B+A, Before and after test period		

Problematic patients' need assessment and *Test orders in advance,* before the test period. Problems in identifying a patient's need occurred due to inadequate information along with complex signs and symptoms at the registration and triage phases of the emergency department patient journey. In addition, laboratory tests were frequently ordered at the registration phase prior to a proper examination and/or use of Point-of-Care instruments and tests. In this way, the nurses felt that the ordering of unnecessary laboratory tests was common in an emergency department environment.

After the completion of the test period, the category *Supported patients' need assessment* was described by the sub-categories *Appropriate tests* and *Deliberate use of instruments*. The nurses emphasized that the utilization of Point-of-Care tests and instruments enabled them to select tests that were most appropriate for the situation at hand. The sub-category *Deliberate use of instruments* indicated that the availability of Point-of-Care instruments and tests did not increase the number of tests performed. The interviewed nurses mentioned that the availability of Point-of-Care instruments and tests could even reduce the number of tests performed and support patients' need assessments.

Preanalytical Phase

One category identified for the preanalytical phase both before and after the test period was *Risky heterogeneity in identification*. Before the test period, this category was described by the sub-categories *Defective identification* and *Untapped potential of wristband*. Emergency department nurses did not ask for patients' identification numbers but only asked for a patient's name. The potential for utilizing wristbands included perceptions about the lack of wristband use within the emergency department. One nurse shared:

Every patient has his/her own wristband, but no, I don't ever use it. (Nurse 4)

Another category that was identified both before and after the test period was *Specific knowledge essential,* which was described by the sub-categories *Issues in finger-prick sampling, Typical in urine sample* and *Notable in throat swab*. The nurses highlighted that both detailed knowledge about collecting samples and appreciating the specific aspects of various types of samples were vital to the correct functioning of an emergency department. Similar topics regarding the quality of finger-prick, urine and throat swab samples were raised during both the before and after test periods. Issues in finger-prick sampling included choice of the right site (second or third finger) and the appropriate size of lancet. Also, the nurses emphasized that it was important to avoid squeezing the finger too tightly and wiping the first drop of blood in order to prevent contamination by tissue fluid. One nurse explained:

For patients with thick skin you have to think about the blade strength to get a good sample. (Nurse 6)

In the nurses' point of view, the specific knowledge necessary for urinalysis includes proper guidance of the patient. In addition, the nurses were aware of the importance of bladder time and its connection to both urine sample quality and reliable test results. One nurse shared:

Those who give urine samples (…) for example, I'll make a comment into the text about the bladder time, like, it's under one hour, so if there are white blood cells in the sample then it's an indicator of UTI. (Nurse 5)

The nurses felt that the specific knowledge important for a throat swab included appropriate sampling, i.e., taken from the back of the patient's throat (both sides). The nurses highlighted the right technique for sample collection and described it to be uncomfortable from the patient's point of view (retch reflex). One nurse explained:

That you really understand the meaning of right technique (…) you have to rub both sides of the back of the throat, not just touch lightly here and there. (Nurse 4)

After the test period, *Risky heterogeneity in identification* was described by the sub-categories *Use of barcodes for identification, Manual identification* and *Errors in identification*. Use of barcodes for identification, which is needed by Point-of-Care testing instruments that automatically enter data into the system by scanning a barcoded wristband, was considered to be a safer practice by nurses. One nurse shared:

I used the barcoded wristband, it was so simple just to scan it. (Nurse 4)

Alternatively, in the sub-category *Manual identification*, nurses highlighted that barcoded wristbands were not utilized in practice, and manual data entry continued even though manual identification was perceived to be time-consuming, demanding and rigorous. According to the nurses, Point-of-Care testing instruments were poorly positioned within the work stations and, for this reason, manual data entry continued. For example, one nurse explained:

I typed the ID number manually, but I was really careful that all the information was correct. (Nurse 5)

To expand on the sub-category *Errors in identification*, the nurses noticed that they had made errors in manual data entry, which led to certain patients being left completely without test results or that test results had been transferred to a wrong patient. One nurse shared:

For me, it happened at least a couple of times that I lost test results because of typos in the identity number. (Nurse 1)

Analytical Phase

Before the test period, the category *Baseline in quality assurance*, described by the sub-categories *Possibility for errors minimized* and *Basic knowledge*, was identified for the analytical phase. The nurses' opinion was that analyzing quality control samples during the use of Point-of-Care instruments increased reliability and minimized errors. The identification of the sub-category *Basic knowledge* demonstrates that the nurses included in this study had an understanding of the basic factors related to quality assurance. For example, the existence and proper use of reference intervals was noted.

Both before and after the test period, the category *Ignorance of quality assurance* was described by the sub-categories *Added workload* and *Unpleasant task*. Similar negative aspects relating to quality assurance were raised by the nurses during both before and after test periods. The sub-category *Added workload* includes perceptions of how analyzing quality control samples adds to a nurse's workload and feels laborious. The nurses also highlighted that quality assurance was time-consuming and the required actions were too frequent. One nurse shared:

It is kind of one more work task, and not kind of, but actually one more work task when you begin your shift. (Nurse 2)

The sub-category *Unpleasant task* included perceptions of noteworthy technical problems during the analysis of quality control samples, which led to repeated measurements. In addition, the nurses did not understand the importance of quality control. Furthermore, the requirements for quality control sample analysis were stressful for the nurses. In such cases, certain nurses ignored the requirements for quality assurance and neglected necessary actions. One nurse shared:

I had some problems inserting the test-strip into the urine analyzer, I wasn't fast enough, so a couple of times I had to repeat the measurements. (Nurse 6)

An additional category, *Responsible party,* was described by the sub-categories *Laboratory's task* and *Task of Point-of-Care testing operator*. The nurses' views regarding the party responsible for executing quality assurance varied both before and after test period. Some nurses felt that quality assurance was most reliably executed by laboratory personnel. In addition, quality assurance was neither a familiar nor a pleasant task for the nurses. One nurse shared:

I think analyzing the quality control sample is the laboratory's task because they have the routine(s) needed for that kind of performance. (Nurse 6)

However, certain other nurses felt that quality assurance should be performed by whoever collects patient samples. These nurses felt that analyzing quality control samples ensures the competency of the Point-of-Care operator, as well as the functionality of the instrument. In this way, a nurse who analyzes the quality control samples independently guarantees that the necessary quality assurance measures are being fulfilled. As one nurse explained:

It is not just so we can assure that the instruments are functioning, but it also confirms that we are performing correctly. (Nurse 7)

An additional category, identified from post-interview data describing the situation after the test period, was *Patient safety responsibility of quality assurance,* which was described by the sub-categories *Functional Point-of-Care testing instrument*, *Confidence of the operator* and *Special detailed knowledge.* The sub-category *Functional Point-of-Care testing instrument* illustrated nurses' perceptions that the analysis of quality control samples could prevent errors arising from nonfunctional Point-of-Care testing instruments. This knowledge helped provide nurses with confidence to trust the test results. One nurse shared:

We can independently eliminate, as far as possible, the chance that the instrument is somehow broken or unreliable. (Nurse 1)

The sub-category *Confidence of the operator* revealed that although quality assurance felt laborious, the analysis of quality control samples trained operators. The analysis of quality control samples was critical to operators gaining a comprehensive understanding of how to operate an instrument, and was particularly important if an instrument was not used on a daily basis. One nurse shared:

It felt laborious, but then again, it was a good thing because it provided experience for using the instrument. (Nurse 7)

The sub-category *Special detailed knowledge* describes comprehension about the requirements for quality control samples (expiry date, store conditions, handling, among others), frequency of quality control measurements, and appropriate use of the reference interval to ensure that results made sense. For example, one nurse explained:

I compared the result from a quality control sample to its reference interval. (Nurse 5)

Post-analytical Phase

Before the test period, the category *Overall picture* was described by the sub-categories *Clinical condition of patient* and *Unexpected test results*, both of which describe nurses' perceptions about the interpretation of test results during the post-analytical phase. The sub-category *Clinical condition of patient* highlighted that nurses took into consideration a patient's clinical condition, which is key to interpreting test results. The sub-category *Unexpected test results* influenced the nurses to order extra laboratory tests in case there was a dis-

crepancy between a clinical condition and laboratory test results.

The category *Patient safety attitude of documentation* was described by the sub-categories *Responsibility for documentation, Documentation as deposit for performed tests* and *Inadequate documentation found problematic* both before and after the test period. The nurses described the sub-category *Responsibility for documentation* as failed documentation, which was seen as unacceptable. In case of inappropriate data entry, corrective actions were taken. One nurse shared:

If you make an error in documentation, you have to correct it by written application from IT-support. (Nurse 2)

The sub-category *Documentation as deposit for performed tests* emphasized the role of documentation in quality of care. The nurses perceived unrecorded tests as unperformed tests. The sub-category *Inadequate documentation found problematic* was described by inadequate documentation, which led to repeated tests, jeopardized patient safety, and delayed nursing. One nurse commented:

Well, it is true, that patient safety is at risk if there is a lack of documentation. (Nurse 3)

The category *IT-solutions for ensuring documentation,* identified only from after the test period, reflected the difficulties of documentation and was defined by the sub-categories *Disregard of documentation, Manual documentation is error prone* and *Preferred automated documentation.* The sub-category *Disregard of documentation* included perceptions that manual data entry of test results was inadequate and was easy to forget to do. The sub-category *Manual documentation is error prone* included nurses' opinions that manual data entry was an unpleasant task, required rigorous work and could jeopardize patient safety through typos. For example, one nurse stated:

To be honest, it was awful to document test results manually, really awful. (Nurse 2)

The sub-category *Preferred automated documentation* pointed out that nurses felt that automated documentation increased patient safety. One nurse shared:

When you have to manually record all, it is more than possible that something remains missing, therefore, automation is more reliable. (Nurse 7)

After the test period, the category *Complexity of test result interpretation* was defined by the subcategories *Doubts of interpreting* and *Confidence on interpreting.* Examining the patient and their condition supported the interpretation of laboratory results and Point-of-Care test results. The technical features of Point-of-Care testing instruments, along with the analysis of quality control samples improved nurses' confidence in their interpretation of results. One nurse shared:

You ponder if the test result is consistent with the patient's clinical condition after examination. (Nurse 1)

Regarding the sub-category *Doubts on interpreting,* the nurses pointed out that the complexity of Point-of-Care testing instruments could hamper the interpretation of test results. In addition, when a nurse questioned sample collection or quality, the interpretation of results became more difficult. One example was given by a nurse:

The more human factors exist on the use of Point-of-Care testing instrument, the more possibilities for you to question your performance. (Nurse 3)

Post-post-analytical Phase

The category *Test results as action,* described by sub-categories *Discharge* and *Doctor's practice,* was identified in the post-post-analytical phase both before and after the test period. The nurses either discharged patients or directed patients to the doctor's practice.

Discussion

According to Quinn et al. (30), there is a possibility that the availability of Point-of-Care tests and instruments can increase inappropriate testing and cause economically unviable situations. Results from this study are not consistent with these concerns. On the contrary, after the test period, regarding the pre-preanalytical phase, the nurses pointed out that implementing Point-of-Care testing supported patient's need assessments through the performing of appropriate tests. In addition, the existence of Point-of-Care instruments can even reduce the number of tests performed via more deliberate actions. In comparison to nurses' perceptions before the test period, the nurses stated in the after test period interviews that laboratory tests were ordered either prior to the proper examination of the patient or as a precaution. According to Laposata & Dighe (18), pre-preanalytical errors happen before the blood sample is ever collected. Therefore, the errors, such as selecting the wrong laboratory test or failing to order the proper test, occur within the mind of the healthcare professional (18). The nurses did not voice concerns regarding the difficulty of choosing the right laboratory test or performing the right Point-of-Care test after the test period. This may be because there was a selected test menu available during the experiment rather than a complex ensemble of laboratory tests (18).

In the field of laboratory medicine, it is a well known fact that the preanalytical phase is error-prone both in terms of the central laboratory testing and Point-of-Care testing (31, 32). For example, errors in patient identification can transfer a certain test result to the wrong patient or prevent the transmission of a result (33). Qualitative data

about emergency department nurses' perceptions reveals risky heterogeneity in patient identification. The pre-interview data from before the test period revealed some alarming facts about identification. Even after the test period, the post-interview data evokes concern about how identification practices could affect patient safety. The nurses admitted that errors were made in identification, which led to test results not being transmitted to patients or transmitted to the wrong patient. In addition, problems in sample collection or handling during the preanalytical phase can lead to faulty test results (34). The interviewed nurses emphasized that specific knowledge about various kinds of sample types was essential. Theoretical and experimental knowledge were both identified as being necessary for successful sample collection and handling. The nurses also had accurate methods for problematic situations related to sample collection.

In its entirety, the emergency department nurses' perceptions about quality assurance during the analytical phase varied considerably. Before and after the test period, in both pre- and post-interview data, the nurses shared negative and positive aspects related to quality assurance. The sub-category *Ignorance of quality assurance* described how the negative attitudes of certain nurses towards quality assurance could impede the utilization of Point-of-Care tests and instruments. A study by FitzGibbon et al. (35) revealed similar results, as almost 70% of respondents (clinicians and nurses) felt that quality assurance was a difficult part of Point-of-Care testing implementation. O'Kane et al. (10) reported that the analytical phase was the most error-prone phase of the Point-of-Care testing process. According to O'Kane et al. (10), Point-of-Care testing operators felt unwilling or unable to analyze quality control samples, and the results from this study support this perspective. In contrast, other nurses showed an understanding of the patient safety responsibility aspect of quality assurance. The nurses gained confidence in operating Point-of-Care testing instruments by analyzing quality control samples and also had special detailed knowledge about quality assurance and its related aspects. Natoli et al. (36) provided similar evidence, as they reported that registered or enrolled nurses considered quality assurance to be an important task rather than a burden.

The post-interview data, collected after the test period, regarding the post-analytical phase demonstrated that the nurses sometimes perceived the interpretation of test results as complex. The pre-interview data, collected before the test period, revealed that nurses order additional laboratory tests in the case of an unexpected test result. Interestingly, perceptions of complex result interpretation only emerged after the nurses had independently used the Point-of-Care testing tests and instruments. Several studies have reported the same problematic doubts about the reliability of Point-of-Care test results among non-laboratory personnel (doctors and nurses) (31, 36, 37). Natoli et al. (36) brought out that nurses, for example, questioned the calibration of Point-of-Care instruments, which then led to doubts regarding the generated test results. According to Jones et al. (38), doctors were concerned about the analytical accuracy of Point-of-Care test results, along with the possibility of missing serious infections. Another study found that under 50% of doctors would base important clinical decisions on results obtained from a Point-of-Care instrument (37). This study showed that the technical features of Point-of-Care testing instruments, analyzing quality control samples and success in sample collection all increase the user's confidence in interpreting test results. In addition, the documentation of Point-of-Care test results caused concerns in the post-analytical phase. Manual documentation was seen as error-prone because it was easy to forget. The nurses included in this study also considered manual data entry an unpleasant task. Therefore, automated documentation was preferred among nurses. Natoli et al. (36) found the lack of automated data flow between Point-of-Care instruments and medical health records to be problematic. Drenck (39) points out the medicolegal problems that can arise from insufficient documentation of Point-of-Care test results. Data from Point-of-Care testing should be recorded into medical health records to prevent the obvious risk that patient-derived data will be scattered around various localities (39). Multiple previous studies have identified the post-analytical phase as an error-prone phase in the Point-of-Care testing process (15, 40, 41), and data from this study support these claims.

Findings from pre- and post-interview data regarding the post-post-analytical phase, the last stage of the Point-of-Care testing process, were consistent in terms of the action taken following test result interpretation. The nurses either discharged patients or directed them to the doctor's practice. Milner & Halverson (42) found that Point-of-Care testing was perceived as valuable in assisting healthcare professionals make decisions such as the discharge or admission of a patient to or from the hospital.

Limitations and Strengths

This study has some limitations. First, the size of the focus groups, 2–3 nurses at once, could be seen as a limitation. However, the group size was determined by the emergency department's human

resources and, as a result, it was not possible to disengage more nurses from the emergency department at the same time without jeopardizing clinical work and patient safety because all interviews were conducted during nurses' working hours. According to previous research, the most appropriate group size would have been 4–6 nurses (20, 24). Also, one of the post-interviews was conducted as an individual interview because of an unexpected change in circumstances. In addition, the total sample size was small (43). Although the research attained data saturation, the speculation for the need of additional interviews is reasonable (29, 43). To compensate for any weakness caused by the sample size, data triangulation in the form of time triangulation was used in this study. The nurses were interviewed at two time points to provide an in-depth understanding of the studied phenomenon (29, 44).

This study aimed for Lincoln and Cuba trustworthiness criteria through dependability, confirmability, transferability, and credibility (27). Furthermore, the study design was formulated with the objective of revealing the authentic voice(s) of emergency department nurses. To ensure dependability, every step and phase of this study is described in a way that is as detailed as possible. For readers to be able to evaluate the adequacy of the analysis, the decision-making process is visualized with figures and a table. The careful review of recordings and transcripts ensured that the findings and conclusions of this study truly originated from the nurses and are not based on researchers' prior assumptions, biases or preconceptions. In this way, the researchers' objective attitude towards both pre- and post-interview data enables the confirmability of results. The presented study is transferable to similar research in other contexts as the settings, methods, and participants were accurately described. To ensure credibility, the collected data were coded and analyzed as accurately as possible and the interpretations of this study were checked by two researchers (27).

Conclusion

Even with conservative estimations, it can be expected that the utilization of Point-of-Care testing will continue to increase in the future and that a broader selection of tests will be available. Patient identification during the preanalytical phase appears to be error-prone, even after data entry automation was enabled. This finding shows that it is highly important that nurses truly grasp how risky heterogeneity of identification can affect patient safety. Future research should also investigate which aspects affect nurses' perceptions of analytical phase quality assurance. It would be important to understand why some nurses saw quality assurance as laborious and unpleasant, while others understood its role in ensuring patient safety. This study identified a few factors that helped nurses trust Point-of-Care test results. For example, an instrument's ease of use, performing the analysis of quality control samples, success in sample collection, and a proper examination of a patient and their clinical status all increased confidence. Therefore, a nurse's own performance considerably affected their ability to trust Point-of-Care test results in the post-analytical phase. This is an important finding and should be considered when purchasing Point-of-Care instruments or training Point-of-Care testing operators.

Information about the frequency of various error types is insufficient if problems exist around Point-of-Care testing following adequate training and support from laboratory staff. Hence, trying to understand the nursing staff's point of view could be a more effective approach. Another interesting topic that could be addressed in future studies is which factors affect the patient safety-centered use of Point-of-Care testing in different clinical settings. This could be studied, for example, by evaluating nurses' perceptions on whether certain educational approaches (e.g., e-learning) are beneficial. A combination of research methods, such as observations, interviews, interventions, and recorded data from medical health records, could provide a comprehensive picture of the influence of Point-of-Care testing. This study offers several promising insights into the overall emergency department nurses' point of view.

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Conflict of Interest

The authors declare no conflict of interest.

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Authorship Criteria

(KK, KM) designed the study. (KK) collected the data. (KK, MK, KM) analyzed the data. (KK, MK, TL, KM) prepared the manuscript. All authors approved the final version for submission.

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