Improving venous blood specimen collection practices
Method development and evaluation of an educational intervention program

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“You have no idea what you’re capable of until you try”
Unknown
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Abstract

Background: About 60%–80% of decisions regarding diagnosis and treatment are based on laboratory test results. Low adherence to venous blood specimen collection (VBSC) guidelines may lead to erroneous or delayed test results, causing patient harm and high healthcare costs. Educational intervention programs (EIPs) to update, improve and sustain VBSC practices are seldom evaluated. After testing a self-reported venous blood sampling questionnaire, the overall aim of this thesis was to evaluate the impact of a large-scale EIP on healthcare personnel’s VBSC practices.

Methods: The study settings were primary healthcare centres (PHCs) in northern Sweden. Participants were VBSC personnel. Data consisted of a VBSC questionnaire of self-reported practices, records of low-level haemolysis index in serum samples (specimen quality indicator), and interviews reflecting VBSC practices. First, experts on questionnaires and VBSC were consulted, and test-retest statistics were used when testing the VBSC questionnaire for validity and reliability. Thereafter, we evaluated the impact of a short, large-scale EIP with a before-after approach comparing self-reported VBSC questionnaire of two county councils. The personnel of the county councils (n = 61 PHCs) were divided into an intervention group (n = 84) and a corresponding control group (n = 79). In order to test changes in blood specimen quality we monitored haemolysis in serum samples (2008, n = 6652 samples and 2010, n = 6121 samples) from 11 PHCs. Finally, 30 VBSC personnel from 10 PHCs reported their experiences. The interview questions were open-ended with reflective elements and the interviews were analysed by qualitative content analysis.

Results: The VBSC questionnaire was found to be valid and could be used to identify risk of errors (near misses) and evaluate the impact of an EIP emphasising VBSC guideline adherence. The intervention group demonstrated several significant improvements in self-reported practices after the EIP, such as information search, patient rest, test request management, patient identification, release of venous stasis, and test tube labelling. The control group showed no significant improvements. In total, PHCs showed minor differences in blood specimen quality. Interviews summarized VBSC personnel experiences in the overall theme: education opened up opportunities for reflection about safety.

Conclusion: This thesis is, to our knowledge, the first to evaluate the impacts of a large-scale EIP on VBSC practices. The VBSC questionnaire and monitoring for low-level haemolysis reflected VBSC practices. The frequently
occurring near-miss markers made it possible to compare and benchmark VBSC practices down to the healthcare unit and hospital ward. The short, general EIP opened up opportunities for reflection about safety and improved VBSC practices in PHCs with larger deviations from guidelines. EIPs that provide time for reflection and discussion could improve VBSC further. Directed EIPs focused on specific VBSC flaws might be more effective for some near misses in VBSC practices, while some near misses must be changed at a different level in the system.

**Clinical relevance:** Our results indicate that monitoring and counteracting the near misses in VBSC practices is a well-functioning preventive action. We propose that the VBSC monitoring instruments (VBSC questionnaire & haemolysis index) we used and the EIP strategy proposed should be tested in additional countries with different healthcare settings. It is suggested that a national program intended to identify near misses and prevent VBSC errors be developed in the healthcare system. General e-learning programs may be cheaper than, and as effective as, the EIP program and may be performed everywhere and any time. Systematic planning, useful for reflection and with focus on the specific elements in a skill, together with VBSC guidelines, could probably increase improvements. Our studies have led to deeper and extended knowledge of the impact of an EIP on VBSC practices. Our results can be used when considering future VBSC practice interventions. Using a model for practical skills in nursing to describe VBSC in a more holistic and less technical way might highlight VBSC as a practical nursing skill.

**Keywords:** Education, Experiences, Guideline adherence, Haemolysis, Intervention, Patient safety, Phlebotomy, Practical skills, Preanalytical errors, Primary healthcare, Questionnaires, Reliability and validity, Venous blood specimen collection
Abbreviations

CG    Control group
CI    Confidence interval
EIP   Educational intervention program
ES    Effect size
Hb    Haemoglobin
HI    Haemolysis index
IG    Intervention group
LID   Laboratory identification
LVN   Västernorrlands county council
Md    Median
OR    Odds ratio
PHC   Primary healthcare centre
VBS   Venous blood sampling
VBSC  Venous blood specimen collection
VBSQ  Venous blood sampling questionnaire
VLL   Västerbottens county council
Original Articles

This thesis is based on four studies; they will be referred by their Roman numerals in the text.


Articles were reprinted with the permission of the publishers: BioMed Central (Studies I & II) and De Gruyter (Study III).
Svensk sammanfattning


Resultat: Venprovtagningsenkäten befanns vara valid och kan användas för att utvärdera personalens följksamhet till provtagningsanvisningar i venprovtagning och identifiera riskhändelser. Interventionsgruppen visade flera signifikanta förbättringar i självrapporterat utförande av venprovtagning såsom förbättrad informationssökning, vila inför provtagning, remissförfarande, kontroll av patientidentitet, användning av stas och etikettering av provrörr. Kontrollgruppen visade inga signifikanta


Preface

My entry into the doctoral studies was via the project on correct venous blood specimen collection practice for increased patient safety. The project identified low adherence to venous blood specimen collection practices in 2007. With the intention to improve VBSC practices, Västerbotten county council developed and performed an educational intervention program in 2009, which will be briefly described later. The research team were interested to know whether the intervention program had an impact on VBSC practices. This is where I became involved in the project.

This thesis is based on interdisciplinary research between the Department of Nursing and the Department of Medical Biosciences, Clinical Chemistry, Umeå University.
Introduction

Laboratory services influence clinical decision making (1, 2). Almost 60%–80% of the most important decisions in diagnosis, administration, and medication are based on laboratory test results (1, 3). Error rates in laboratories range between 0.05% and 10% (4, 5). In Västerbotten county council (VLL) around 6 million clinical chemistry analyses are performed each year (6), and this means that 3000–600,000 of those may be erroneous. Deficiencies in venous blood specimen collection (VBSC) practices may lead to a repeated collection procedure, and delay in diagnosis and treatment. Jeopardised test results also mean additional patient suffering and high costs for the society as well as for the individual patient (7–10). VBSC is strictly regulated by international (11, 12) or existing practice guidelines and regulations (13, 14). VBSC personnel, unfortunately, largely deviate from those guidelines (15–19) which increases the risk for an error to occur. Errors in VBSC usually depend on human mistakes in relation to the system (20–22), indicating that they could be prevented. To be able to evaluate such prevention programs, it is necessary to use well-functioning outcome measures tested for validity and reliability. Thus, to further improve future intervention programs increased knowledge about VBSC practices has to be gained.
Background

Initially, the background presents the theoretical framework, followed by a literature review of international as well as national research. The theoretical framework in this thesis is based on practical skill performance in nursing.

Theoretical framework

In nursing research there exists a lack of evidence-based knowledge focused on hands-on performance in clinical settings. However, this focus is as important as taking care of the mind and emotions (23). Attention should be given to physical and practical aspects of how nurses develop and perform practical skills (24). VBSC is a nursing skill that demands theoretical knowledge as well as good practical skills (23, 25). A theorisation based on a model of practical skill performance in nursing (26) might contribute to a more holistic approach to VBSC.

Nursing practical skills

In the nursing literature different opinions about the focus in nursing have been discussed during the last decades (27). De Tornyay argued that practical skills are less important than communication, leadership, and decision-making (28), while Quinn pointed out that practical skills are the main purpose in nursing education (29). During Florence Nightingale’s era, as well, good routines, accuracy, and caring were described as important in practical skills, and practical skills were considered the foundation of nursing (30). Nurses and technology are linked (24, 27). One hundred years ago, fever persons were treated with a bath, whereas today a bath is a complement to medical treatment. Following such changes, the impact of technology has increased in the nurses’ role (27). Patients feel more safe and comfortable if nurses work with safe techniques (31).

Nursing practical skills are historically understood as an art or as a psychomotor skill. Nursing as an art was in focus during the first half of the 20th century and was described as the refinement of practical skills towards the art of taking care of the patient. In 1950–1970, practical skills were defined more narrowly with the term motor skill, but after 1970 replaced with psychomotor skill (23). However, high-quality nursing performance demands psychomotor skills and affective skills as well as nurses’ critical creative and reflective thinking abilities (32, 33). Both ethical reasoning and
communication skill and theoretical knowledge are needed to know what to do in different kinds of actions and situations (25, 33). In 1999 a broader understanding of nursing practical skills was defined, constituting three dimensions: performance, intention, and understanding of nursing discipline (23). It is important to update and sustain knowledge about, for example, guidelines in clinical practice to avoid having work become obsolete, routine traditions (33, 34).

Bjørk and Kirkevold developed a model of practical skill performance in nursing as a part of an observation study (26). Their analysis resulted in six non-hierarchy categories: substance, sequences, accuracy, fluency, interaction, and caring comportment (Figure 1). These categories together are considered to reflect the good performance of a practical skill. The model has been successfully used in nursing research, nursing education, and nursing practices (35, 36). The focus in my thesis is to evaluate adherence to guidelines and blood specimen quality, and to describe participants’ experiences of VBSC after participating in an EIP. In comparison with the model, this thesis mainly focuses on substance, sequences, and accuracy (Studies I, II, and III). Study IV also highlights the categories fluency, integration and caring comportment.

![Figure 1. The model of practical skill performance, © Ida Torunn Bjørk 1999.](image-url)
Substance is described as including relevant content in skill performance, instructions, and information. It means, for example, that nursing and medical knowledge is needed and that guidelines should be followed when performing a practical skill such as VBSC. Instruction and information should be relevant to the skills in focus. Sequences involves performing the components of a practical skill, and giving instruction and information in a logical order following guidelines and local routines and in accordance with the regulations. Accuracy refers to an exactness in each step during the practice and correctness in instruction and information, for example, always checking that the name on a referral is correct, that precise instruction is given regarding preparation procedures, and that correct information is given about, for example, pain relief. Fluency means performing a practical skill without interruption and giving an impression of ease and smoothness. Being well prepared, having all materials available, and working in a suitable environment increases fluency. Integration means adapting the practical skill to the patient and the situation by harmonising parallel aspects of the skill, such as performance, physical support, and verbal interaction, that is, being attentive to the total needs of the patient. Caring comportment means creating an atmosphere that is respectful, accepting and encouraging. It also includes personnel taking the patient's feelings into account, as well as the patient's reaction to the instrumental steps of the practice (26, 36, 37).

Nurses perform and are responsible on a daily basis for practical skills and their quality of healthcare (25, 31). Errors due to nurses lacking practical skills may cause harm to patients (31, 38). Errors cannot be separated into nursing or medical errors, because nurses work in an intermediary space between general healthcare workers and the patient. In the healthcare system, nurses are in a frontline position to recognise and prevent potential errors (34, 38).

**Patient safety and prevention of errors**

Two international descriptions of patient safety are “the reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum” (39) and “prevention of errors and adverse effects to patients associated with health care” (40). A Swedish definition is “protection from healthcare related injury” (41). Since the late 20th century, intensive efforts to identify avoidable injuries in healthcare have been made both internationally and nationally (2, 19–21, 40, 42–46). Still, after all these efforts with the purpose to improve healthcare, no major changes has been seen globally (20, 47–49). About 27%–70% of all medical injuries are preventable, as measured in different healthcare settings (20, 21, 45). In Sweden, approximately 100,000 patients
suffer from avoidable injuries each year due to errors in the healthcare (42). Similar figures have been shown in other countries (20, 21, 45).

In Sweden and internationally, similarly risks for errors have been reported (42, 50–54). Errors that may lead to adverse events are most often caused by human mistakes in relation to the system (2, 4, 42, 51–53, 55), and less often by technical failures (52–54). Human mistakes may arise due to forgetfulness, poor motivation, carelessness (50), stress, work environment (55), incorrect knowledge or usage of guidelines (51), and lack of attentiveness or inappropriate judgement (38). Human mistakes may be active or latent. Active mistakes are unsafe acts attributable to and caused by personnel in the frontline in direct connection with the patient. They are often recognised at the moment they occur, while latent mistakes are weaknesses within the system, often distant and unrecognised for a long time (50). Mistakes can lead to a single adverse event or to minor but more frequent events that may go undetected (45). However, to a large extent, latent mistakes can be identified before an adverse event occur (50, 54).

Prevention of complications is an important goal of good nursing care (38, 56). A general way to eliminate errors has been to report adverse events and thereafter try to learn from them (10, 34, 57, 58). Underreported adverse events range between 50% and 96% annually (21, 58–61). Therefore, assessment of near misses that can lead to adverse events and occur more often than adverse events may add noticeably more value to healthcare improvement than sole focus on adverse events (59, 62). Intervening healthcare personnel acting as the last line of defence may be able to prevent injuries (45, 63–65). Errors performed by frontline personnel could eventually be avoided by improved knowledge and awareness of the risk of error in a given situation (64). Who is responsible when an error occurs does not matter for patients. What matters is whether the error is detected before it causes any delay in diagnosis, or causes outright patient harm (66). Designing for standardisation, understanding errors, and finding different solutions of adaption to situations are vital considerations for improving patient safety (9, 67–69).

**Improving healthcare by use of guidelines**

To reduce errors and thus increase patient safety, several methods have been used (70, 71). One important method is to use clinical guidelines, which reduce errors in healthcare if they are followed (72, 73). Guidelines are described as syntheses of best available evidence that support decision-making, standardise practices, and attempt to speed translation of evidence-
based practices (70, 74–77). There are concerns about guidelines and their effectiveness (75, 77). Users of standards can apply the recommendations unthinkingly and standards are not always adapted to clinical practice (77). A review concluded that lack of agreement, limited familiarity, and lack of awareness are main barriers to adoption of guidelines (74). However, improved adherence to, and use of, guidelines has been shown (72, 73, 78–80). For example, guidelines have reduced blood-stream infections and also decreased costs for the healthcare system (72, 79). Compliance with guidelines is strongly related to the way the guidelines are developed and implemented (71, 75, 81). Short guidelines that are easy to understand have a better chance of being followed than more complex ones (70, 71). Checklists are also experienced as helpful when working in a constant hurry (56, 61, 72). However, local adjustments of international or national guidelines may be necessary so that recommendations are suited to different contexts (75, 76).

There are few official international recommendations or guidelines on VBSC, such as the H3-A6 VBSC guideline issued by the Clinical and Laboratory Standards Institute (11) or the guidelines on drawing blood, published by the World Health Organization (12). The existing guidelines are quite short with point-by-point guidance. A study showed that strict compliance with a VBSC guideline can improve quality of care (80). VBSC is performed in different contexts and by different professionals and should be strictly performed according to guidelines to ensure reliable test results (60, 76). As methods for VBSC change over time, guidelines should be updated followed by intervention programs (17).

**Improving healthcare through interventions**

To effectively optimise adherence to guidelines, intervention programs could be used. “Interventions refer to treatments, therapies, procedures, or actions implemented by health professionals to and with clients, in a particular situation, to move the clients’ condition toward desired health outcomes that are beneficial to the clients” (82). Several different interventions occur in clinical practice and focus on individual professionals, patients, groups, teams or specific aspects of the organisation of care. A review pointed out that interventions with mostly effective outcomes are education with a combination of strategies, such as interactive small group meetings and reminders. However, in general, no approaches to transferring best available evidence to practice have been appropriate for all changes in all situations (71).
In this thesis we evaluate a large-scale educational intervention program (EIP) initiated, developed, and performed by the VLL in 2009. Large-scale programs may be planned actions, such as education performed by a healthcare provider to prevent errors and thereby improve the quality in healthcare. Programs often vary in conditions and start and finish at different times (77, 83). Large-scale intervention programs are difficult to standardise and need to be tailored to suit the target. A problem with large-scale intervention programs is that there are many criteria for success of a program, which should include short- as well as long-term follow-up outcomes (83). Outcome, then, should be assessed from different perspectives. A negative factor in large-scale intervention programs is that each program and situation is unique, and generalisations are difficult to make. However, the description of the program and the context allows others to decide the relevance of the program for their own contexts. Little evidence of the effectiveness of large-scale interventions has been presented (83), so further research may identify factors needed for successful implementation (84).

**Quality assurance of laboratory services**

In contrast to large-scale intervention programs that are difficult to standardise (83), laboratory services have internal as well as external quality control systems. An example of internal control is laboratories’ practice of continuously calculating a median value for all patients’ sample analyses to see if these values are stable over time. External quality control includes specimen comparisons with other national laboratories, and also comparisons between countries (85, 86), primarily to determine whether the concentration of the measured analyte is correct. The Swedish organisation EQUALIS is an example of such a national organisation aiming to ensure analytical quality and thereby patient safety by providing external quality control programs (87). Accredited laboratories show higher quality than laboratories without accreditation programs (69).

**Laboratory services and analysis**

Laboratory services provide testing of patient samples, usually of blood but also of other specimens such as tissues, urine, and faeces. A venous blood test can, for example, identify release of plasma proteins troponin I & T which are of diagnostic value for myocardial injury (85). A total of 6000 unacceptable blood samples per million were identified in an international study including 10 nations, of which Sweden was one (88). A wide variety of
definitions and methods are used to identify laboratory errors (3, 4, 7). Errors among laboratories are heterogeneous worldwide, while the likelihood of detecting a laboratory error is small, and the real frequencies of errors are not known. One example is incorrect ordering of analyses, where probably only the care provider has a chance to detect the error (3, 7, 66). Most errors occur because of lack of, or low, adherence to standardised protocols (4, 53, 68, 89). Of laboratory errors, 25%–30%, have been estimated to have some effect on patient care, while 6%–10% may translate into adverse events (90). Presumably, identified errors are the tip of an iceberg, and near misses (39) are of most importance to identify and reduce (91) to ensure patient safety (41).

**Venous blood specimen collection practices**

This thesis focuses on VBSC and refers to venous blood samples drawn by needle from peripheral veins (85, 92). VBSC is the most common way of obtaining blood for laboratory testing (85, 92). Blood or serum tests assess the concentration of several substances, such as plasma proteins and electrolytes in the extracellular fluid. For example, potassium moves across cell membranes and may shift, depending on health conditions. Increased or decreased potassium levels may result in cardiac arrhythmias (85, 92).

VBSC can be viewed as a dependent practical skill, meaning that different kinds of professionals perform and encompass the totality of VBSC practices (82). Worldwide, different professionals perform VBSC, but venipuncture should be performed by educated and competent personnel (14, 92) because VBSC practices demand theoretical knowledge as well as good practical skills (25, 26, 36, 92). In Finland, trained laboratory technicians collect most of the blood samples in primary healthcare centres (PHCs) (93). Physicians, registered nurses, enrolled nurses and biomedical technicians are often mentioned as phlebotomists (18, 68, 93). In Swedish PHCs, VBSC is almost always performed by trained enrolled nurses, registered nurses, or a few biomedical technicians (18).

**Patient’s perspectives of VBSC practices**

Phobia about VBSC is common and estimated to occur in up to 3.5%–4% of all collections (92). Phobia is anxiety caused by a previous bad experience in a specific situation, often leading to avoidance behaviour (25). VBSC is considered as something VBSC personnel just do, and patients are not always asked for consent (94). Patient consent is essential for all healthcare
procedures, including VBSC. Asking for consent and giving information about the procedure, or analysis should be done and can reduce patient anxiety (25). Nurses should never underestimate the impact on the patient undergoing VBSC. Correct VBSC practices reduce anxiety and pain for patients undergoing VBSC and also lead to reliable test results (92).

**The total testing process including VBSC**

The total testing process starts with the ordering of a laboratory test and ends with its interpretation. Thus, the total testing process consists of several interrelated processes and each of them involve a serial of steps (Figure 2) that all can result in errors (7, 95).

![Flowchart of the total testing process](image)

**Figure 2.** The total testing process, inspired by Lundberg (1981) and Plebani (2006).

The total testing process is usually divided into three phases; *preanalytical, analytical, and postanalytical* (Figure 2) (2, 7, 89, 96), while some authors have added also a pre-preanalytical phase and a post-postanalytical phase (97, 98). The majority of published articles includes pre-pre in the preanalytical phase and post-post in the postanalytical phase (7, 96). The focus of this thesis is the preanalytical phase (excluding the pre-pre phase)
encompassing the VBSC steps before the blood specimen is analysed in a laboratory (3, 5), which is the most error-prone phase (46%–77%) (5, 99, 100) in the total testing process. In Spain, 7.4% of the samples were found to contain errors in the preanalytical phase (101). The analytical phase, occurring in the controlled laboratory environment with more technical equipment, is less error prone (10%–15%) (5, 8, 53, 100) and has contributed to reducing the frequencies of errors in the analysis process because of extensive efforts to improve safety over a long time (89). Also the postanalytical phase, including delivery of test results and so on (Figure 2) (3, 5, 7, 66), is less exposed to errors (8%–23%) (8, 53) compared to the preanalytical phase. Common consequences of errors in the total testing process are delay in care (24%), time or financial costs (22%), suffering or harm (11%), and no consequences (26%) (91). In the total testing process, 73% of detected errors are classified as preventable (5).

Preanalytical venous blood specimen collection procedures and error rates

Preanalytical VBSC practices comprise several overlapping steps. Below, each part will be described in a logical order.

Patient preparation procedures

Patients need to be correctly prepared before VBSC for certain requisitioned analyses. For example fasting (11, 102) and patient rest (13, 102) are common preparation procedures. Only 6% of VBSC personnel in PHCs reported that they always allowed the patient to rest (17) at least 15 minutes in a sitting position before VBSC, compared to 18% of hospital VBSC personnel (103). That the patient should rest in a sitting position for 15 minutes prior to sampling is recommended (13, 102), because changes of body position affect the plasma volume. Changes in plasma volume might influence the test results for some analyses, for example, albumin, aldosterone, LDL, and HDL cholesterol, which increase by 5%–15% (102, 104). Test results are compared with previous results or reference intervals. So, sampling following the same procedures is important to ensure reliable and comparable test results (88, 104). Reliable test results lead to less repeated sampling and minimises patient suffering.
**Identification procedures**

In this thesis, identification procedures include patient identification procedures, labelling of test tubes, and test request management. During a 6-month period, 352 samples per million were found to have identification errors in an Italian hospital (68). They constituted approximately 27% of all preanalytical errors and included failure to check the patient’s identity and failure to include the patient’s name in the request. Similar figures are reported in other studies (5, 7, 16). All identification errors have similar consequences, as the errors may result in delayed or missed diagnosis, mix-up of patients, wrong treatment, or even death (22, 43, 105–107). An adverse event is estimated to occur in 1 of every 18 identification errors (108). Identification procedures have been improved in recent years due to computerised systems. Computer systems have reduced errors in name, identification number, and care unit on the test request, but have not eliminated the risk of mismatching patients during VBSC (5). An international recommendation is to have two identifiers when collecting blood samples for clinical testing (105).

**Patient identification procedure.** Söderberg pointed out that only 54% of VBSC personnel from PHCs reported that they always asked patients to state their name and identification number, and only 5% reported that they always identified patients by photo ID (17). Patient misidentification constitutes around 27% of all preanalytical errors (22). Patient identification should be performed by healthcare personnel with competence in the procedure, and identification should be made by means of an identification wristband or identification paper. If this is not possible, VBSC personnel should ask patients for their full names and identification numbers. In some cases relatives can certify a patient’s identity (14). Appropriate patient identification procedures are of outmost importance to optimise patient safety which is a prioritised goal in nursing and health care (7, 47, 109, 110).

**Labelling of test tubes.** Mislabelling is common (111), and accounts for about 50%–65% of all identification problems (68, 108). One study estimated mislabelling of test tubes at 1 error in every 165 specimens (88). In Sweden in 2009, the National Board of Health and Welfare reported 40 adverse events during blood transfusion; 20 of these adverse events were due to incorrect labelling of test tubes (112). In PHCs, 86% of VBSC personnel reported labelling the test tubes themselves, and only 12% of them reported labelling the test tubes prior to sampling (18). In hospitals, 22% of VBSC personnel reported labelling the test tube at a later occasion away from the patient (16). Labelling errors may be latent, as there is no direct interaction between the patient and the healthcare professionals who interpret and
report the test results (88, 105). In Sweden, test tubes should always be labelled prior to blood collection (14, 113), but guidelines (11, 13) are contradictory, and some recommend labelling in close proximity to the patient. Other suggestions to decrease labelling errors are barcoded wristbands and new handheld computer resources for both patient and sample (114).

Test request management. Test request errors have been found in several studies (16, 18, 65, 91), and are estimated to range between 4% and 8% of all errors in the total testing process (91, 108). As many as 10%–25% of VBSC personnel have reported not always signing the test request (16, 18, 106). As well, paper-based test requests are an important source of errors in the preanalytical phase. The information on test requests should be compared and rechecked with the patient’s full name and identification number to ensure patient safety (14, 99).

Venipuncture

Problems in the preanalytical phase are often associated with venipuncture (phlebotomy), for example, empty filled tubes, wrong type of collection tube (22, 99, 115), and incorrect use of venous stasis (116). Venous stasis is used to make the veins more visible and easier to localise and puncture (11). Only 12% of VBSC personnel in PHCs removed stasis as soon as possible (17) in line with recommendations (11, 13). Around 60% stated that they removed stasis after collection (15). Research points out that prolonged stasis may influence test results, by, for example, increasing the level of albumin and potassium concentration (116–119). Recommendations are to release the venous stasis as soon as possible when receiving blood or within a maximum of one minute (11, 13). An incorrect applied tourniquet might become uncomfortable and create pain for the patient (92) as well as causing harm as a result of resampling (111).

Venous blood specimen handling

Multiple factors are associated with incorrect handling of blood specimens. Collection tube centrifugation delays, missing tubes, clotting, incorrect inversion, and incorrect storage of samples occur (111). In Italy, 871 clotted samples were identified per million samples (68). In PHCs 71% stored test tubes vertically after specimen collection (17), and in hospitals 90% stored test tubes lying horizontally (15). Test tubes should stand up vertically according to the guidelines (11, 13). In PHCs 66% of personnel stated they
always invert test tubes after sampling (17) compared to 62% in hospitals (15). The recommendation is to invert test tubes 5–10 times (13) for mixing the additives with the collected blood (11). Too many inversions will increase haemolysis in samples and no inversion will increase the risk for clotting of specimens, factors that may influence the test result or lead to repeated sampling (120, 121). However, research and evidence is disputed in this area (122, 123).

**Haemolysis**

Breakdown of red blood cells accompanied by release of haemoglobin and other intracellular components into the surrounding plasma is called haemolysis (124, 125). Haemolysis may occur in vivo or in vitro. In vivo haemolysis (the premature destruction of red blood cells within the circulation) may occur due to genetic, ethnic or diseases factors. It is rare and constitutes up to 3.2% of all haemolysed samples (125–127). This thesis will focus on in vitro haemolysis due to preanalytical handling of the venous blood specimen (124, 127, 128).

In vitro haemolysis is the main cause of sample rejection by the clinical chemistry laboratory. As many as 60%–65% of all rejected samples may be due to haemolysis (65, 99, 126). In one study 13% of tests were rejected due to high level of haemolysis (129). In VLL 0.8% of 8849 samples from PHCs had a haemolysis index (HI) level ≥50 (0.5 g/L free haemoglobin (Hb)), which is the rejection level for potassium and iron in serum samples (128). A single haemolysed sample may cause the absence of 20 or more test results (3).

Several factors that cause in vitro haemolysis have been reported to depend on the way the blood specimen is drawn (124, 126, 128, 130–135), for example, location of venipuncture (121, 124, 130–132), poor knowledge or skill (124), prolonged tourniquet (124), large tubes (115), thin needles >22 gauge (124, 127), inappropriate mixing of tubes (121, 124, 126, 135), unsuitable transport, and long delay before tube centrifugation (124, 135). Blood samples from the emergency department are more often haemolysed than samples from other units (128, 132–134, 136). One reason for this is a large proportion of sampling from peripheral venous catheter in the emergency department (121, 129, 131, 132, 136, 137). Haemolysed samples may lead to delay of diagnosis and need of repeated sampling (128, 138). So, nurses who works with a proper technique increases patient safety and increase patients’ experience of safety which means that quality of VBSC practices improve (31).
Information search procedures

Problems in the preanalytical phase may occur due to incorrect information search procedures, since updated, correct information is crucial in order to draw samples according to VBSC guidelines (9, 120). Online guidelines were implemented in northern Sweden before 2007, but only 18%–60% of VBSC personnel reported using them, and only 20%–45% pointed out that they never asked a colleague about VBSC information (16, 18). Such behaviour increases the risk for unreliable information. Online manuals can provide correct, updated information that is available also for personnel out in the field. Improved information search techniques might motivate VBSC personnel to search updated guidelines on-line (139, 140).

Monitoring venous blood specimen collection practices

Generally, the aim of monitoring programs is to decrease the risk of adverse events. To develop such programs, it is essential to identify potential risks and methods aimed to identify risks. Monitoring programs should be tested for validity and reliability in a representative population (3, 86). Few errors during VBSC practices are actually reported (141). However, even a low incidence of laboratory errors among billions of tests worldwide has an impact on public health and patient safety, given the large number amount of analyses performed (66). In addition, several steps are involved in the testing procedure that could cause damage and suffering for the patient. Thus, it is important to develop valid and reliable instruments aimed at identifying VBSC risks. Below, methods such as a questionnaire, assessment of sample quality, interviews, and observations suitable for monitoring VBSC practices are described.

Questionnaires. Generally, questionnaire surveys are cost effective and easy to coordinate, and not very time consuming. A large geographical area can be covered and questionnaires offer a great possibility to ensure confidentiality (142–144). Self-reported questionnaires could be valuable in order to identify near misses (15). However, postal distributing of questionnaires increase the risk of drop outs and repeated reminders are often necessary to get an acceptable response rate (142). Self-reported answers may also produce overestimating or underestimating in the source of data. In addition, invalid questionnaires might also lead to unreliable results (145), why it is nessasary to test questionnaries in respect to validity and relability.

Blood sample quality. The determination of HI in automated analysers is an efficient method for detecting haemolysis. Assessment of frequent occurring
mildly haemolysed specimens has been suggested as a suitable marker for pre-analytical blood sample quality (128) instead of assessment of the relatively infrequent number of analytically rejected samples. Thus, it is possible to evaluate interventions intending to improve VBSC practices at ward/PHC level.

**Observations.** Observations can be successfully used to collect information on people’s behaviour, nonverbal communication, activities and environmental conditions (144). Direct observation of the underlying mechanisms and causes of VBSC errors in the preanalytical phase can yield information on what to improve in clinical practices (5, 68, 146). Carraro and co-authors observed VBSC performance in direct action for one week at three wards in an Italian hospital. In addition, they identified all noncompliance events in VBSC procedures during a 6-month study period.

**Interviews.** Personal interviews are useful to describe structure and practice in healthcare (147, 148). Interviews may provide a deeper understanding of the preanalytical phase (149) and provide additional information in relation to other quantitative data in order to understand phenomena and situations (142, 144, 150, 151). Lundberg performed semistructured interviews to reveal constraints affecting accident investigation practices that lead the investigation forward (150). Unlike a questionnaire, an interview allows rephrasing of questions and explanations. Open-ended questions in an interview allow for longer answers compared to closed questions in a questionnaire (142). However, both interviews and observations are costly in both time and money (144).
Rationale

Patient safety is considered a priority in modern healthcare and is essential in nursing. Avoiding patient injury and providing the best possible care is a continuous struggle. Laboratory results following VBSC constitute a major cornerstone in the diagnosis and treatment of patients. VBSC errors may cause delay in diagnosis, repeated sampling, and erroneous treatment. These errors jeopardise patients’ health and safety.

The general practice of VBSC is described in local and national guidelines that should be followed by healthcare personnel. The literature review and our earlier studies show that low adherence to VBSC guideline practices is common and can cause serious errors such as incorrect identification procedures, incorrect specimen collection practices, and incorrect handling of specimens. In addition, there is a lack of implementation advice in VBSC guidelines, as well as a lack of continuous personnel education aiming to update and sustain proper VBSC practices. In general, large-scale EIPs are common, but their effectiveness has been explored in a rudimentary way at best. It is therefore important to evaluate the impact of large-scale EIPs on VBSC practices. To achieve trustworthiness in results, it is important to test outcomes in respect to validity as well as reliability such as stability.

No study, as far as I know, investigated the implementation of an EIP for VBSC practices by monitoring specimen haemolysis or by using a validated venous blood sampling questionnaire (VBSQ). The instruments (sample haemolysis and a self-reported questionnaire) have hitherto not been used in an evaluation process. Research focusing on the personnel’s own experiences of VBSC is also lacking. VBSC personnel’s experiences of VBSC are crucial when developing VBSC education programs. In the future, such knowledge will be of utmost importance in optimising EIPs aimed at reducing errors in VBSC.
Aims

After testing a self-reported venous blood sampling questionnaire, the overall aim of this thesis was to evaluate the impact of a large-scale educational intervention program on healthcare personnel’s VBSC practices.

Specific aims

Study I: To test a recently developed questionnaire on self-reported venous blood sampling practices for validity and reliability.

Study II: To evaluate the impact of a large-scale educational intervention program on primary healthcare phlebotomists’ adherence to venous blood specimen collection guidelines.

Study III: To monitor the percentage of haemolysed venous blood specimens of eleven PHCs before and after a large-scale intervention to assess possible improvements of venous blood specimen collection practices.

Study IV: To describe primary healthcare personnel’s experiences of venous blood specimen collection practices after participating in an educational intervention program.
Methods

Research context and population

There are approximately 1100 PHCs in Sweden and about one third of them are privately owned. In 2009, there were about 40 million visits to PHCs and those visits accounted for about 17% (€3.7 billion) of the total healthcare costs. In northern Sweden, PHCs are mainly publicly owned, with several professional employees who have responsibility for population health within a geographical area (152). Swedish PHCs have similar organisations, personnel set-up, personnel education, and organisation of healthcare (153). This thesis includes VBSC personnel working in PHCs, except Study I which also includes a few participants from the university hospital. The PHCs are located in rural as well as urban areas in three counties, VLL, Västernorrland (LVN), and Jämtland, all in northern Sweden. The counties have about 614,000 inhabitants. In this thesis, PHCs (Study III) were divided according to distance to the laboratory in the same manner as in Söderberg et al.’s study (128). The urban area refers to PHCs within 1–17 km from a laboratory and rural PHCs refers to PHCs more than 17 km from the nearest laboratory. The distribution of VBSC personnel in PHCs is typical of Sweden. The term VBSC personnel will be used henceforth and includes biomedical technicians, enrolled nurses and registered nurses.

Research design

This thesis has its base in Wallin’s and Söderberg’s theses (154, 155). Their results showed low adherence to VBSC guidelines, which motivated VLL to develop and implement a mandatory large-scale EIP focused on improving adherence to VBSC guidelines. The four studies included in my thesis reflect interconnected quantitative and qualitative components. Therefore, we used both quantitative and qualitative methods. In 2010, the validity process was described and a test-retest was added (Study I) to examine whether the VBSQ used was stable enough to use for evaluations. It is essential to use a comparative before-after design to produce strong evidence when evaluating educational programs. This approach increases trustworthiness, and changes can be explained by the program itself (83). Thus, using a follow-up design, we systematically evaluated the EIP’s impact on VBSC practices (Studies II and III). In study II, we compared self-reported questionnaire answers within an intervention group (IG) and within a control group (CG); comparisons between the two groups were also carried out. In Study III, a follow-up study comparing blood specimen quality before and after the EIP.
within a single group of PHCs was used. We also performed face-to-face interviews to describe VBSC personnel’s experiences of VBSC after participating in the EIP (Study IV). Figure 3 presents an overview of the research plan and study design.

**Figure 3.** An overview of the research plan and the data collected and analysed in this thesis. The black dots represent the studies in my dissertation; the grey dot shows the EIP, and the light grey dots show the basic data collected by Johan Söderberg and Olof Wallin.

### The educational intervention program

The VLL executive board gave permission for a large-scale EIP (Figure 3), provided it would be cheap and cause minimal interference with daily healthcare work. Following these restricted premises, laboratory instructors with experience of teaching developed and performed a 2-hour EIP regarding pre-analytical practices, including a specific lecture on VBSC guideline practices. Almost all hospital, laboratory, and PHC VBSC personnel (n = 2171) in VLL, northern of Sweden, participated in the education (in this thesis only PHCs are included). Participation ranged from 8 to 89 VBSC personnel in each lecture session. One third of the IG (n = 27) in Study II participated through live Internet link. Educational substance
(Table 1) was based on the guideline the National Handbook for Healthcare (13) and local directives (113), both almost identical to the CLSI H3-A6 guideline (11). The EIP was mandatory and included three parts: 1) Participating VBSC personnel had to read the national VBSC guideline (13) as a part of the EIP and signify that they had read the guidelines before the education. 2) Attendance at two oral lectures as compulsory. The first included VBSC practices concerning information regarding local non-adherence to preanalytical practices (154, 155), and emphasis was also put on how to avoid haemolysis (121, 128, 134–136) and the importance of several preanalytical practices (Table 1). The second lecture focused on collection of microbiological specimens. 3) Participants who responded adequately to six written examination questions regarding VBSC received a competency certificate valid for four years. An example of a question was: “When should the stasis be released?” More examples are described in Study II.

**Table 1.** Overview of VBSC procedures that were in focus during the EIPs as well as the studies reporting the results at follow-up

<table>
<thead>
<tr>
<th>Preanalytical VBSC procedures</th>
<th>Educational content</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation procedures</td>
<td>Fasting status</td>
<td>II, IV</td>
</tr>
<tr>
<td></td>
<td>Need of rest prior to sampling</td>
<td>II, III, IV</td>
</tr>
<tr>
<td></td>
<td>Need of relaxation of muscles and body</td>
<td>III, IV</td>
</tr>
<tr>
<td></td>
<td>Recommended needle size</td>
<td>III</td>
</tr>
<tr>
<td>Identification procedures</td>
<td>Correct patient identification procedure</td>
<td>II, IV</td>
</tr>
<tr>
<td></td>
<td>Labelling procedures</td>
<td>II, IV</td>
</tr>
<tr>
<td></td>
<td>Checking of data against referral and labels</td>
<td>II, IV</td>
</tr>
<tr>
<td>Venipuncture</td>
<td>Recommended order of test tubes</td>
<td>IV</td>
</tr>
<tr>
<td></td>
<td>Correct use of stasis</td>
<td>II, III, IV</td>
</tr>
<tr>
<td></td>
<td>Syringe use</td>
<td>III, IV</td>
</tr>
<tr>
<td>Handling of specimens</td>
<td>Inversion of test tubes 5–10 times</td>
<td>II, III, IV</td>
</tr>
<tr>
<td></td>
<td>Use of automatic test tube inversion</td>
<td>II, III, IV</td>
</tr>
<tr>
<td></td>
<td>Storing of test tubes</td>
<td>II, IV</td>
</tr>
<tr>
<td>Information search</td>
<td>Information search via internal network</td>
<td>II, IV</td>
</tr>
<tr>
<td>Other factors taught but not evaluated</td>
<td>Filling of the tube, intravenous cannula, clotting of samples, influence of medication, hygiene routines, date &amp; time, diurnal variation</td>
<td></td>
</tr>
</tbody>
</table>

**Studies I and II**

**Participants**

To achieve face validity (Study I), a focus group consisting of seven enrolled nurses with experience of practical VBSC was consulted. For content validity, nurses and senior researchers from the Department of Nursing as well as
physicians and senior researchers from the Department of Medical Biosciences, were consulted as well as laboratory instructors. In our test-retest (Study I), a total of 28 VBSC personnel participated. In Study II, a total of 213 VBSC personnel were invited and 163 (77%) from 61 PHCs participated (Study II, Figure 1). Those from VLL constituted the IG and those from LVN the CG. Background characteristics of the participants are shown in Table 2. Comparing the background characteristics, we found that enrolled nurses were over represented in the IG (Table 2).

**Table 2.** Background characteristics of the participants

<table>
<thead>
<tr>
<th>Background data</th>
<th>IG (n=84)</th>
<th>CG (n=79)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female n</td>
<td>79</td>
<td>79</td>
<td>0.059</td>
</tr>
<tr>
<td>Male n</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>VBSC personnel’s professional status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered nurses n</td>
<td>26</td>
<td>50</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Enrolled nurses n</td>
<td>56</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Biomedical technicians n</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Age (Years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age Md (Q1; Q3)</td>
<td>55 (49; 60)</td>
<td>56 (49; 62)</td>
<td>0.604</td>
</tr>
<tr>
<td>Range</td>
<td>28–65</td>
<td>38–70</td>
<td></td>
</tr>
<tr>
<td><strong>Numbers of years employed at the job site</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Md (Q1; Q3)</td>
<td>11 (7; 27)</td>
<td>11 (5; 20)</td>
<td>0.045</td>
</tr>
<tr>
<td>Range</td>
<td>0–37</td>
<td>0–38</td>
<td></td>
</tr>
<tr>
<td><strong>How often personnel performed VBSC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every day n</td>
<td>61</td>
<td>44</td>
<td>0.028</td>
</tr>
<tr>
<td>Every week n</td>
<td>19</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Every month or less n</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

IG = Intervention group, CG = Control group, *p* = significant test to detect differences at baseline between groups

**The venous blood sampling questionnaire**

The VBSQ (Supplement 1) was initially developed to assess self-reported VBSC performance (15) in accordance with the national guideline (13). An instruction containing information on how to complete the questionnaire was located on the first page. It was pointed out that the respondents should state how they usually performed VBSC practices and not how they knew it should be performed. The VBSQ included questions on background characteristics (6 questions), patient identification and collection of specimens (4 questions, 10 items), sample storage and information seeking (2 questions, 7 items), test request management and test-tube labelling (4 questions, 12 items), and frequency of error reporting and suggestions (3
questions, 8 items). The majority of questions were answered using a four-point ordinal scale; Never, Seldom, Often, and Always, and one question was answered yes/no. Four “by other means” items are retained in the VBSQ, but were excluded from Study I because of a high rate of missing internal data.

**Data collection**

All VBSQs were given a code to enable sending of new questionnaires to non-responders. The questionnaires were delivered by postal mail to the PHCs, and a person at each PHC assisted in the distribution and collection of the VBSQs. An information letter was distributed together with the questionnaire, describing the purpose of the survey and explaining that participation was voluntary. Participants were asked to put the completed VBSQ in an anonymous reply envelope, seal the envelope, and send it back to the investigators. In Study II, a reminder questionnaire was sent to the non-responders after two weeks and after four weeks. In Study I, we collected data at two occasions from focus group members. The focus group members provided comments on the VBSQ’s substance, length, and clarity. From the dialogues with professionals, data on the questionnaires and different aspects of VBSC were obtained. For stability, a test-retest was performed with 3–4 weeks between the test and retest. In Study II, the IG VBSQs from 2007 were paired with completed questionnaires from 2010–2011, 6 months after the EIP. The CG completed the follow-up questionnaire in April 2010, and data were investigated undergoing the same procedure, except for the EIP.

**Analysis**

In Study I, face validity was achieved through focus group meetings with discussions. During the development process, extensive efforts were made to ensure that each item was easy to understand, was clearly outlined, and could not be misinterpreted. Discussions within the focus group were followed and transcribed by members of the research group. To achieve content validity, dialogues with professionals, including senior researchers (with experience of questionnaire design), nurses, and physicians were performed. Laboratory instructors from the local laboratory and the experts rewrote the content in some questions and ensured that the questions were reasonable and in accordance with the guidelines. To examine the stability, Spearman’s rank correlation was used to measure the association; Kappa coefficient (K) and percentage agreement (%A) were used to measure the agreement for questions and items in the test-retest. VBSQ items were
accepted as stable if answers passed at least one of two set criteria. Criterion two complemented criterion one. In those cases, combinations of the measures used were judged to be acceptable.

- Criterion one: K ≥ 0.61 = good or rs ≥ 0.7 or %A ≥ 90%.
- Criterion two: K ≥ 0.51 = moderate and rs ≥ 0.6 or K ≥ 0.51 = moderate and %A ≥ 80%.

In Study II, the paired VBSQs were compared within groups by Wilcoxon signed rank test for continuous data and by McNemar test for dichotomised data. VBSQs between the IG and CG were analysed by Mann-Whitney U-test for continuous data and Chi-square for independence for dichotomised data. Questions and items with missing answers were excluded from the study. In Studies I and II, SPSS® version 18, (IBM, New York, USA), was used for all statistical analyses, except for non-symmetrical K values, (Study I), and effect size (ES) values, (Study II), which were manually calculated by the author. ES is a way to quantify the size of the differences between two groups (156). The statistical significance level was defined as p < 0.01, Study II.

**Study III**

**Subjects**

Serum blood samples were monitored for HI in the IG, before (year 2008, n = 6652) and after (year 2010, n = 6121) the EIP. In 2008, we collected samples from both rural (n = 2039) and urban (n = 4613) PHCs. In 2010 the numbers of samples were 1902 for rural and 4219 for urban PHCs. Information about age and sex of the patients (Study III, Table 3) was available from the laboratory information system.

**Haemolysis**

It has been suggested that monitoring the HI from blood specimens provides a suitable marker for preanalytical quality (91, 128). The samples investigated were intended for routine clinical chemistry analyses on Vitros 5,1 automated analysers (Ortho-Clinical Diagnostics, Inc., Rochester, NY, USA). Blood specimens were considered haemolysed at an HI ≥15, corresponding to ≥150 mg/L free Hb, which was the detection limit for the Vitros 5,1. The analysers automatically determine the HI in all blood samples. HI determination for the Vitros 5,1 was authenticated by serial dilution of a purified haemolysate into two serum specimens with a low
degree of haemolysis. The amount of free Hb in these specimens was measured using a spectrophotometric assay (157). The HI and the amount of free Hb had a linear relationship ($R^2 = 0.9865$) (158), and 1000 mg/L of free Hb corresponded to an HI of 99. Data from the laboratory information system were merged by using the corresponding laboratory identification (LID) number for each analysis. Specimens with duplicate LID numbers (specimens where more than one analysis was requested) were excluded. Cases with missing HI values due to machine error, and a few cases with invalid sex and age data, were also excluded.

**Data collection**

The HI in blood samples from eleven PHCs was investigated during a 3-month period before and after the EIP. VBSC personnel collected blood using needles, and not intravenous catheters, with recommended gauge between 19 and 23 gauge (20) in plastic 3.5 mL evacuated serum separator test tubes with an inert polymer gel barrier and a clot activator (cat. no 367957, Becton Dickinson, Franklin Lakes, NJ, USA). After allowing for clotting 30 min, the specimens were centrifuged locally or in the laboratory for nearby PHCs. Test tubes were transported in cooled insulated boxes ($5\sim12^\circ$C), twice a day from the urban, and once a day from the rural PHCs. The total file information contained the name of the ordering PHC, specimen HI, and age and sex of the patients.

**Analysis**

In Study III, the data were analysed using Chi-square for independence and Mann-Whitney U-tests, where appropriate. The PHCs were divided according to distance to the laboratory; the urban group included six PHCs and the rural group included five PHCs. We used multiple logistic regression analysis mainly to explore the association between haemolysis ($HI \geq 15$) and year (before/after intervention), with consideration for sex, age, and PHC. Odds ratios (OR), confidence intervals, and $p$-values ($p$) are reported. The statistical significance level was defined as $p < 0.01$. 
Study IV

Participants

VBSC personnel (n = 35) who had completed a VBSQ in 2007, completed the EIP in 2009–2010, and answered the same questionnaire between September 2010 and June 2011 were asked to participate. A total of 30 VBSC personnel from 10 PHCs accepted participation. Of those, three were men. Participants worked at PHCs in urban or rural areas and varied in respect to age, working years, and profession. VBSC personnel consisted of enrolled nurses (n = 18), registered nurses (n = 11) and a biomedical technician (n = 1). The median age was 57 years (range 32–65) and median length of time working in PHCs was 20 years (range 1–37).

Interviews

VBSC personnel were informed about the study by a postal letter, and thereafter asked for participation by follow-up phone call. Face-to-face interviews were performed by the first author (KB) at the participant’s workplace during working hours. All interviews were conducted using open-ended questions with reflective elements and were informal in nature. The interview guide addressed experiences of VBSC after participating in an EIP. The first question was, “Could you please tell me about your experiences of VBSC after participating in the VBSC EIP?” The answers were followed by questions such as “Tell me more about it” and “Please could you give me an example of that?” Each interview lasted 17–44 min (Md = 22 min). The interviews were tape-recorded and transcribed verbatim.

Analysis

In Study IV, we analysed the text using qualitative content analysis (159) with an inductive approach (160). The interviews were read through to gain a sense of the content. Thus, text that did not respond to the aim was excluded, such as descriptions on capillary or bacterial specimens. We analysed manifest as well as latent content. The text was divided into meaning units and thereafter condensed and marked with codes. The codes were compared for similarities and differences and sorted into eight categories. The categories were abstracted and three subthemes were formulated. Finally, a consensus was reached and a theme was formulated after several discussions with co-authors. In addition, relevant quotations along with our findings are presented.


**Ethical consideration**

The research plan, including Studies I and II (Dnr 06-104M) and Studies III and IV (Dnr 2010-355-32M additions to Dnr 06-104M) were approved by the Regional Ethical Review Board in Umeå. The EIP was mandatory, and the heads of the PHCs gave final permission to participate in the EIP. In Studies I, II and IV the participants were assured of confidentiality in the information letter and also informed that they could withdraw from the survey or stop the interview at any time without declaring any reason. Participants gave their informed consent to participate and were also informed that data would only be presented at group level. In Study IV participants also received verbal information on the study and were able to choose the time and place of the interview. The participants were informed that all information would be handled confidentially; for example, the questionnaires and transcript interviews were decoded and kept confidential in a locked space. Only the researcher had access to the codes and the corresponding names. The possible risks of the project were seen as low. Risks such as transferring feelings and shame were considered to be outweighed by the benefits of improved VBSC practices.
Results

The presentation of results is based on the main findings of each study.

A validated venous blood sampling questionnaire

In Study I, we tested a recently developed questionnaire on self-reported VBSC practices for validity and reliability.

The VBSQ (Appendix 1) was found to have acceptable validity and reliability. It included 19 questions of which 9 had in total 34 underlying items (Study 1, Table 1). The VBSQ was found to have face and content validity. The test-retest analysis demonstrated that all questions and items had acceptable stability; a total of 82% fulfilled the reliability acceptance criteria. Criterion one was fulfilled by 71% and criterion two by 68% of all questions and items. Items 7c, 8b, 8c, 10a, 16a, 18e, and 18f did not fulfil the acceptance criteria (Study 1, Table 1). Items 7c, 18e, and 18f were removed from the questionnaire, while items 8b, 8c, 10a, and 16a were not stable, but were retained because the items were interrelated with other underlying items.

The process of establishing validity resulted in modifications. Answer alternatives were reduced from five to four (the alternative “sometimes” was removed), and some questions were modified to suit the PHC’s setting. Focus group meetings resulted in further modification of some questions and also the removal of a question about order of test tube collection and centrifugation. Questions and items were considered clearly outlined and easy to understand. It was judged that the number of questions included could be completed in a reasonable amount of time. Thereafter, the VBSQ was judged by experts in VBSC and questionnaire design to have acceptable content validity, and face validity was established by the focus group with vast experience.

Adherence to venous blood specimen collection guidelines

In Study II, we evaluated the impact of a large-scale EIP on primary healthcare personnel’s adherence to VBSC guidelines.

When evaluating the EIP, we found that self-reported adherence to guidelines had significantly improved in several items (10 out of 32) in the IG (Study II, Table 3 and 4), while the CG showed no significant
improvements at all. In order to get another understanding of the results we present percentage of self-reported VBSQ responses (Table 3).

Table 3. Percentage of self-reported VBSC practices in the IG and CG

<table>
<thead>
<tr>
<th>Questions</th>
<th>IG (n = 75 – 83)</th>
<th>CG (n = 71 – 79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7d Always/often identify by checking photo-ID</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>8c Never release stasis when specimen collection is finished</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>9 Always allow the patient to rest &gt;15 minutes prior to VBSC</td>
<td>21</td>
<td>37</td>
</tr>
<tr>
<td>11a Never use the old paper-based laboratory manual</td>
<td>41</td>
<td>70</td>
</tr>
<tr>
<td>11b Always/often use updated online laboratory manual</td>
<td>77</td>
<td>95</td>
</tr>
<tr>
<td>11f Never/seldom ask a colleague for VBSC information</td>
<td>35</td>
<td>54</td>
</tr>
<tr>
<td>11f Never/seldom phone the laboratory for VBSC information</td>
<td>78</td>
<td>92</td>
</tr>
<tr>
<td>15f Always check that the test request and test tube (barcode) number match</td>
<td>54</td>
<td>70</td>
</tr>
<tr>
<td>16b Always/often label the test tube prior to sampling</td>
<td>31</td>
<td>53</td>
</tr>
<tr>
<td>19a Reported to have enough knowledge for daily work with VBSC</td>
<td>49</td>
<td>76</td>
</tr>
</tbody>
</table>

Information search and preparation procedures. IG participants reported more often searching for information using the Internet and internal networks. They more seldom used printed papers, and seldom asked colleagues for information (ES = 0.23–0.33, p < 0.001–0.003), (Study II, Table 3). Participants also reported that they more often allowed the patients to rest for the recommended time before venipuncture (ES = 0.27, p = 0.004), (Study II, Table 4). All improvements in the text above regarding information search procedures were significantly different from those of the CG.

Identification procedures. After the EIP, IG participants stated that they more often checked that the test request and test tube identification number matched (ES = 0.23, p = 0.003), and more often labelled test tubes at the patient’s side before specimen collection (ES = 0.49, p = <0.001), (Study II, Table 3) in accordance with guidelines. They also significantly improved control of patient’s photo identification (ES = 0.34, p = <0.001), (Study II, Table 3). All findings above regarding identification procedures were significantly improved for the IG, but no differences were found in the between-group comparisons with the CG.
Venipuncture. The IG participants reported shorter venous stasis time (ES = 0.22, p = 0.006) after the EIP compared to before the EIP (Study II, Table 3).

Venous blood specimen handling. No changes were noted for test tube inversion or test tube storage within or between the groups.

Table 4. Percentage of self-reported VBSC practices in the IG and CG

<table>
<thead>
<tr>
<th>Questions</th>
<th>IG (n = 74–82)</th>
<th>CG (n= 70–79)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007 (%)</td>
<td>2010–2011 (%)</td>
</tr>
<tr>
<td></td>
<td>2007 (%)</td>
<td>2010–2011 (%)</td>
</tr>
<tr>
<td>7a Always/often ask for name and identification number</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>94</td>
<td>96</td>
</tr>
<tr>
<td>7b Never identify by previous knowledge of the patient</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>42</td>
</tr>
<tr>
<td>8a Always/often release stasis before first sample is drawn</td>
<td>52</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>52</td>
</tr>
<tr>
<td>8b Always/often release stasis during sampling</td>
<td>66</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>74</td>
<td>55</td>
</tr>
<tr>
<td>8d Never/seldom keep stasis as long as necessary</td>
<td>41</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>10a Always invert the test tube immediately</td>
<td>55</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>81</td>
</tr>
<tr>
<td>10b Always/often use automated reverser</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>72</td>
<td>77</td>
</tr>
<tr>
<td>12a Never store test tubes lying on work-bench</td>
<td>67</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>91</td>
</tr>
<tr>
<td>12b Never store test tubes in the pocket</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>12c Always store test tubes in a test tube stand</td>
<td>84</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>90</td>
</tr>
<tr>
<td>13 Never let someone else mark the sampling time</td>
<td>74</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>73</td>
</tr>
<tr>
<td>14 Insert sampling time 0-30 minutes after sampling</td>
<td>45</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>62</td>
</tr>
<tr>
<td>15a Always compare identification number with test request</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td>90</td>
</tr>
<tr>
<td>15b Always sign the test request</td>
<td>92</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>99</td>
</tr>
<tr>
<td>15d Always check the information on the test request, if somebody else has completed it</td>
<td>72</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td>87</td>
</tr>
<tr>
<td>15e Always adjust sampling time, if the marked time differ with more than 30 minutes from the actual sampling time</td>
<td>49</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>58</td>
</tr>
<tr>
<td>16a Always/often label test tubes before approaching the patient</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>16b Always/often label test tubes after VBSC</td>
<td>75</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>97</td>
<td>92</td>
</tr>
<tr>
<td>16d Never label test tubes at a later occasion</td>
<td>87</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>90</td>
</tr>
<tr>
<td>16e Never let somebody else label the test tube in advance</td>
<td>84</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>16f Never let somebody else label the test tube after VBSC</td>
<td>95</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>19b Proper collection and handling is considered a priority at my PHC</td>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>54</td>
</tr>
</tbody>
</table>
Blood specimen quality

In Study III, we monitored the percentage of haemolysed venous blood specimens from 11 PHCs before and after a large-scale intervention (the EIP), to assess possible improvements of VBSC practices.

The total percentage of specimens with HI ≥ 15 during July to September 2010 was 11.8% compared to 10.5% in 2008 ($p = 0.022$), showing a degradation of blood specimen quality. Rural PHCs had a higher percentage of haemolysed specimens before the intervention and higher reduction of haemolysis in the univariate analyses (Table 5); therefore, it was essential to compare rural with urban PHCs. Divided into groups, rural PHCs (Nos 4, 5, 9–11) demonstrated a significant ($p < 0.001$) reduction in haemolysis (OR = 0.74, CI = 0.651–0.851) after intervention, whereas the urban PHCs demonstrated a significant ($p < 0.001$) increase (OR = 1.45, CI = 1.912–1.765) in haemolysis (Study III, Table 3). Of the urban PHCs, Nos 6 and 7 had a significantly higher percentage of haemolysed specimens in 2010 compared with 2008, whereas the others were unaffected.

Table 5. Percentage of haemolysed specimens (HI ≥ 15, free Hb ≥ approx. 150 mg/L) and HI 95th percentile in 11 PHCs before (July–September 2008) and after (July–September 2010) the EIP

<table>
<thead>
<tr>
<th>PHCs 2008</th>
<th>n’</th>
<th>HI ≥ 15 (%)</th>
<th>HI 95th</th>
<th>PHCs 2010</th>
<th>n’</th>
<th>HI ≥ 15 (%)</th>
<th>HI 95th</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHCs all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>2039</td>
<td>15.8</td>
<td>23</td>
<td>Rural</td>
<td>1902</td>
<td>12.8</td>
<td>22</td>
<td>0.007**</td>
</tr>
<tr>
<td>Urban</td>
<td>4613</td>
<td>8.2</td>
<td>18</td>
<td>Urban</td>
<td>4219</td>
<td>11.4</td>
<td>22</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>1</td>
<td>472</td>
<td>6.4</td>
<td>16</td>
<td>1</td>
<td>559</td>
<td>5.9</td>
<td>16</td>
<td>0.864</td>
</tr>
<tr>
<td>2</td>
<td>713</td>
<td>7.2</td>
<td>16</td>
<td>2</td>
<td>628</td>
<td>8.3</td>
<td>19</td>
<td>0.502</td>
</tr>
<tr>
<td>3</td>
<td>1223</td>
<td>7.6</td>
<td>17</td>
<td>3</td>
<td>989</td>
<td>9.7</td>
<td>21</td>
<td>0.063</td>
</tr>
<tr>
<td>4</td>
<td>477</td>
<td>9.0</td>
<td>18</td>
<td>4</td>
<td>396</td>
<td>9.6</td>
<td>19</td>
<td>0.834</td>
</tr>
<tr>
<td>5</td>
<td>307</td>
<td>17.6</td>
<td>24</td>
<td>5</td>
<td>363</td>
<td>12.0</td>
<td>22</td>
<td>0.059</td>
</tr>
<tr>
<td>6</td>
<td>609</td>
<td>7.9</td>
<td>18</td>
<td>6</td>
<td>606</td>
<td>16.5</td>
<td>27</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>7</td>
<td>1138</td>
<td>8.3</td>
<td>18</td>
<td>7</td>
<td>1089</td>
<td>13.3</td>
<td>23</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>8</td>
<td>458</td>
<td>13.7</td>
<td>24</td>
<td>8</td>
<td>348</td>
<td>16.1</td>
<td>24</td>
<td>0.409</td>
</tr>
<tr>
<td>9</td>
<td>362</td>
<td>13.8</td>
<td>21</td>
<td>9</td>
<td>364</td>
<td>12.1</td>
<td>21</td>
<td>0.561</td>
</tr>
<tr>
<td>10</td>
<td>649</td>
<td>14.9</td>
<td>21</td>
<td>10</td>
<td>541</td>
<td>10.9</td>
<td>21</td>
<td>0.049</td>
</tr>
<tr>
<td>11</td>
<td>244</td>
<td>32.0</td>
<td>34</td>
<td>11</td>
<td>238</td>
<td>24.4</td>
<td>31</td>
<td>0.080</td>
</tr>
</tbody>
</table>

Rural = PHCs 4, 5, 9–11; Urban = PHCs 1–3, 6–8
n’ = number of specimens, P = chi square for independence
*significantly increased percentage of haemolysed specimens, **significantly decreased percentage of haemolysed specimens
Experiences of venous blood specimen collection practices

In Study IV, the aim was to describe primary healthcare VBSC personnel’s experiences of VBSC practices after participating in the EIP.

In the participants’ experience, the education opened up opportunities for reflections on safety. They became aware of risks, achieved improvements in clinical practice and felt strengthened in working as usual. Reflections on safety revealed during the analysis could be identified in almost all subthemes and in relation to the EIP. Table 6 presents an overview of categories, subthemes and theme.

### Table 6. Overview of categories, subthemes, and theme revealed during the analysis

<table>
<thead>
<tr>
<th>Categories</th>
<th>Subthemes</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification procedure</td>
<td>Becoming aware of risks</td>
<td>Education opens up opportunities for reflection</td>
</tr>
<tr>
<td>Environmental disturbances</td>
<td></td>
<td>on safety</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td></td>
<td>Standardised ways of working</td>
</tr>
<tr>
<td>Transfer of information</td>
<td></td>
<td>Achieving improvements in clinical practice</td>
</tr>
<tr>
<td>Accuracy in clinical practice</td>
<td></td>
<td>Becoming aware of risks</td>
</tr>
<tr>
<td>Doing as usual in a correct way</td>
<td></td>
<td>Doing as usual in a correct way</td>
</tr>
<tr>
<td>Doing as usual in an incorrect way</td>
<td></td>
<td>Feeling strengthened in working as usual</td>
</tr>
</tbody>
</table>

**Becoming aware of risks**

The participants experienced having become aware of risks. Participants related that low accuracy and communication problems could be risky when performing identification procedures. Participants reflected on environmental disturbances and pointed those out as a risk for VBSC errors. They described the physical environment as varying from arranged to completely unfamiliar places. They also reported that they sometimes worked in a stressful and noisy atmosphere and also worked according to a deficient work plan that they not always could affect by themselves. The participants reflected on lack of knowledge among VBSC personnel. Not knowing the content in the VBSC guidelines was experienced as risky. Before the EIP several of the participants did not know how to label test tubes and to perform VBSC with the correct sequence and the correct order of tubes. After education, the participants increased their understanding of several VBSC practices. Transfer of information was described as a risk for misunderstanding and sample delay. The participants described that patients and/or the professionals sometimes received wrong or no information at all, which was experienced as a safety risk. In other cases,
information and referral might reach the patient but not the PHC’s personnel. It occurred that wrong orders were entered into the computer.

**Achieving improvements in clinical practice**

Participants reflected on safety and reported that they had achieved improvements in clinical practice. To ensure quality, having *standardised ways of working* was described as important. Participants described how they improved in following guidelines, such as using stasis for a shorter period of time and inverting test tubes more in line with the national guidelines. One PHC had bought bags especially for sampling, with space for all materials and a carrier to store the tubes standing as instructed. The participants described better routines, such as performing one thing at a time, and reflected on improvements in planning, being well prepared, making systematic checks, and having all the materials available. Standardised ways of working contribute to increased *accuracy in clinical practice*. The participants described being more careful after the education and having learned about the importance of comparing the identity with the test request. They were also more accurate in labelling test tubes. The EIP motivated and reminded them of the consequences that could appear if they were careless.

**Feeling strengthened in working as usual**

Some participants reported that they did not learn anything new during the EIP. However, some of these felt recognised and confirmed that they were already working as instructed; they went on *doing as usual in a correct way*. The VBSC education motivated and reminded them of consequences that could appear in daily VBSC practices. Participants experienced the EIP as positive and pointed out that VBSC was made visible due to the education. However, there were participants that went on *doing as usual in an incorrect way*. They experienced having learned new things during the EIP, but still did not work according to the new instructions. They just did not want to change their routines.
Discussion

After testing a self-reported VBSQ, the overall aim of this thesis was to evaluate the impact of a large-scale EIP on healthcare personnel’s VBSC practices. Our main findings showed that the VBSQ was valid. Thus, it could be used to monitor VBSC practices, identify near misses and evaluate the impact of an EIP emphasising VBSC guideline adherence. Secondly, following the large-scale EIP, several specific VBSC practices were significantly improved, indicating that the EIP had an impact on the adherence to guideline practices. Thirdly, the percentage of haemolysed specimens was significantly reduced in rural PHCs but significantly increased in urban PHCs after the EIP. Finally, using methods to describe experiences, it was obvious that the large-scale EIP opened up opportunities for reflections about safety.

To understand the results in this thesis, findings will be discussed in relation to the system perspective (64, 161). Organisations working with a system perspective allow improvements on several levels in the system (64), which can create opportunities for VBSC personnel to perform their skills correctly (66, 110). The reason that some VBSC personnel did not improve in guideline adherence can also be discussed in relation to the system perspective. Specific findings will also be interpreted in relation to the model of practical skill performance (26). Further, the model of practical skill performance in nursing makes it possible to describe VBSC in a broader perspective. As a tentative suggestion, a monitoring program intended to identify and eliminate VBSC errors and provide implementation advice for VBSC educational programs will be discussed.

Opportunities for preventing venous blood specimen collection errors

To understand the extent to which the environment influences various events in the organisation, the system can be divided into four different parts: the people working on the frontline, local work environment (PHCs), local organisational structures, and national or international structures. Each part should effectively protect against errors: if one barrier fails, the next barrier should ensure patient safety (161). Barriers may act preventively, but as long as many errors are latent and undetected, it is difficult to develop effective barriers (62, 74). Errors in VBSC often occur in the preanalytical phase (16, 18, 100), are related to human mistakes, and are often undetected (53). These errors can be prevented by using the model of
practical skill performance in nursing as a basis to ensure that every part in the process of VBSC will be achieved. The model describes practical skills in nursing as complex and points out that a good practical skill in nursing is performed when all six categories are integrated (26). The modified model below reflects VBSC practical skills in nursing and could be a support in VBSC education (Figure 4).

**Figure 4.** A model of VBSC practices in nursing, modified from Figure 1, Björk 1999.

*To be prepared is crucial when performing VBSC*

Staying up to date with relevant content in skill performance, instruction, and information is referred to as *substance* in the model of practical skills in nursing (26). Increased patient health has been associated with the use of...
retrieved information (162). Therefore, having updated content on VBSC procedures is important, since VBSC guidelines and laboratory methods change over time (139). Thus, it is particularly important that healthcare personnel are aware of how to search and have access to correct information in the internal network. This thesis showed increased use of information via internal networks after, compared to before, the large-scale EIP. From a system perspective, the VBSC EIP was a good initiative to ensure that personnel have the qualifications to work safely, which indicates that the EIP is considered as good for implementing information search procedures. Information that is needed and readily available (38, 162), as well as interventions that concern use of computerised information, often constitutes effective interventions (71).

Errors may also occur due to deficient transfer of information between healthcare units (Study IV). Participants described situations where patients and/or professionals received incorrect or no information. This could correspond to the category integration in the practical skill model pointing out that personnel’s verbal interactions with patients and colleagues are important nursing skills (26). System errors in nursing and primary care due to deficient transfer of information are common (38, 51, 163, 164), and its consequences may lead to increased visits to the healthcare service and delayed diagnostics and treatment (164). However, such deficiencies cannot be improved by a short large-scale EIP, but are considered more as a local organisational structure problem (51, 161). Thus, information routines within and between professionals, units, and organisations must be considered in future interventions and research.

Another preanalytical preparation procedure is patient rest, which could correspond to the category substance in the practical skill model. After the EIP, still only 37% reported following guidelines (Study II) regarding patient rest prior to sampling. However, participants described changes in the routines and now allowed patients to rest in the waiting room before VBSC (Study IV), which also can be related to the category sequence. Using a reflective tool as a complement to a general education may accelerate improvements and increase personnel’s knowledge (36). On a system level, to improve safety, routines regarding rest prior to sampling could easily be standardised (38). This is important and could be improved by implementing routines but should not be prioritised in an education directed to the personnel, where the identification procedure should be prioritised as number one (17, 103).
**Accurate identification procedures ensure patient safety**

Since patient misidentification is not easily detectable (165) and reporting of identification errors may cause blame for the personnel (110), assessment of near misses and development of successful interventions are of most importance. An opinion paper from 2012 stated that improving patient identification is an ongoing challenge in all types of blood collection procedures (166), and also a critical issue in other healthcare areas (165). Using the VBSQ, the IG (Study II) significantly improved patient identification by photo ID. They also more often checked that the test request matched the test tube identification, indicating increased identification accuracy. The results in Study IV showed that low accuracy was a risk for deterioration of the patient identification procedure. Accuracy due to the model in nursing means exactness in each step during the VBSC practices (26). Patient identification procedures performed with accuracy include several steps, such as identifying the patient and confirming that the patient’s name and identification number are correct in comparison to referrals and labels (14). Those steps are typically important safety barriers in the frontline personnel’s routines and are intended to prevent patient identity mix-up at the last defence. Nurses have an important role in minimising nursing errors (110, 111). Other patient identification procedures and test request management procedures had not improved (Study II) after the EIP. From a system perspective it may partly be due to the organisational structure. Participants in Study IV working at the VLL were actually responsible for the municipality VBSC personnel’s registering and signing of referrals. In accordance with the regulation, personnel are by themselves responsible for signing test requests (167). In these cases it was not possible. The VLL personnel had to register and sign, whereas the municipality personnel collected the venous sample. The VLL personnel described how not taking responsibility for the co-workers’ tasks could lead to suffering for the patients. Thus, clinical reasoning and good judgement are fundamental skills in VBSC nursing practices (110).

Study II showed that most participants labelled the test tubes before or after VBSC but alongside the patient, which could correspond to as the categories sequence and accuracy in the practical skill model. Some authors have suggested that labelling specimens immediately after collection alongside the patient should be considered as acceptable practice (105). Still, despite the EIP, participants sometimes labelled the test tube at a later occasion away from the patient, which is unacceptable. This kind of informal routine involving low accuracy has in other areas caused patient deaths, when the nurse did not follow guidelines (38). Understanding when and why things go wrong is fundamental for patient safety in nursing. From a system
perspective, attempts have been made to decrease human mistakes. Use of barcoded wristbands (117) is an attempt from an organisational level, while double-checking the patient’s identity (105) is a routine created for VBSC personnel at the last line of defence (67). In Sweden, there is also a regulation that states that test tubes should be labelled prior to specimen collection (14). However, there are VBSC guidelines (11, 13) that recommend labelling test tubes alongside the patient before leaving the side of the patient, before or after specimen collection. The wide variation in responses (Study II) indicates that unclear recommendations can make it difficult for personnel to know whether they should adhere to the regulations or the guidelines (74, 111). In addition, VBSC instructors or other healthcare teachers may become less credible when what they teach is unclear (74). Regarding regulations and national guidelines, the organisation at a national level has a large responsibility to preserve and ensure patient safety (74, 168). When a barrier aimed to ensure safety fails, such as contradictory guidelines and regulations, errors may occur in the lower levels of the organisation (4, 67, 110, 111, 169). Thus, it may be necessary to standardise and clarify guidelines so they cannot be interpreted as contradictory.

Our findings indicate that some participants improved their patient identification procedure without increased risk awareness, but rather due to other colleagues’ opinions. Decisions on how to perform a nursing skill are influenced by collaboration with colleagues: nurses seek to adhere to other nursing personnel and often put their own opinions aside (170). Education that stimulates reflection and discussion and increases awareness may then maximise improvements in identification procedures to ensure patient safety. Some participants (Study IV) did not change their behaviour at all, as they thought that the changes were not important for patient safety. From a system perspective, unit-based nurses with a leadership role are noted as a key factor for improvements in the local work environment if they support personnel during the change process (61, 163, 171). Management and leaders also have a large responsibility to support and motivate their personnel to make improvements (169, 172). Personnel who feel valued and supported by the management have a better possibility to change routines (63, 148, 172–174). Positive personnel attitudes towards research (175) and motivation are an important factor in influencing personnel behaviour (163).

**Venipuncture and specimen handling culture**

Releasing venous stasis (Study II) and also using shorter venous stasis (Study IV) after having undergone the EIP led to more reliable test results. Incorrect use of venous stasis may be explained by incorrect sequences of
performance (26, 36). Use of stasis before cleaning the patients’ skin means that venous stasis time probably will be longer than one minute and thereby influence the test results (80). A proposal from that study was to clean the venipuncture site and let it dry before stasis. This is also suggested in the Swedish national guideline (13). From a system perspective this problem can be identified as an error on the frontline. By using the model as a reflective tool when discussing VBSC performance against the guidelines in education and clinical practice, a problem like this can probably be identified beforehand.

In vitro haemolysis is a consequence of incorrect venipuncture or blood specimen handling. Söderberg concluded that variation in HI among PHCs reflects varying preanalytical conditions (128). We concluded that monitoring HI could be used to identify near misses. We evaluated whether blood specimen quality had improved after the EIP (Study III). The rural PHCs had significantly lower numbers of haemolysed blood specimens after the EIP, while the urban PHCs showed a significant increase of haemolysed samples after the EIP. However, rural PHCs had a higher percentage of haemolysed samples at baseline, which indicates that the EIP might be effective in PHCs demonstrating VBSC practices with larger deviation from guidelines. VBSC practices were also quite stable within each PHC between years 2008 and 2010 which might be attributed to preserved cultures in the local work environment. From a system perspective, organisational structures can be described in which VBSC practice takes place, while the culture of a PHC may be multifaceted and include the VBSC personnel’s beliefs and assumptions. Thus, there is a need to consider the VBSC personnel’s resources for achieving successful changes (174). Pronovost described culture as the way healthcare personnel do things around each unit. He also pointed out that there is a lack of interventions that have been shown to improve the work culture. Improving work culture must focus on the people at the frontline, because culture is local. Results from interventions should be reported to the personnel involved in the intervention. If the culture is not responsive to the intervention, there is no point in measuring it (176).

**Caring comportment and complex work environment.**

To create an accepting and respectful atmosphere during VBSC practices are essential in nursing care and refer to *caring comportment* in the practical skill model (26, 36) and may decrease patient anxiety (92). Caring comportment includes to taking the patient’s feelings and reactions into account. In Study IV, the participants described how conflicting emotions
arose when they needed to hold a patient during VBSC. Nurses’ ethical practice is a complex process of reasoning and decision-making that also is influenced by personal and work environments (170). Ethical decisions are often based on medical and nursing knowledge, and individual values and experiences (170, 177, 178). The participants described lack of knowledge as a risk that might influence their actions and decision-making in different situations (Study IV).

An adaption of practical skill performance is needed when working in varying environments; this is referred to as integration (26). Environmental disturbances were experienced as risks that could lead to mistakes (Study IV) and jeopardise patient safety. Physical obstacles in the work environment can make it difficult to use safe nursing practices, that is, caring comportment (148, 179). For example, having several VBSC sites in the same room (Study IV) was experienced as a source of decreased integrity for the patient, if the patients were sampled simultaneously. Decreased integrity may cause stress and anxiety for the patient (180). From a system perspective, the physical environment may be difficult for personnel to influence (180) because rebuilding and changing the physical work environment occur at an organisational level (50). Environmental disturbances in Study IV take high workload into consideration, as it could contribute to low guideline adherence (169). A calm and silent physical space is important to ensure a work environment with fewer distractions (180). VBSC practices without interruption correspond to fluency, which is crucial for good performance and give an impression of ease and smoothness (26, 36). From a system perspective, fluency is also related to the local work environment, as to be well prepared with proper routines and available materials may increase fluency and create a sense of security for the patient. Fluency may be improved by repeated experimental learning followed by reflections and discussions (178, 181). Observation studies to further identify not only fluency but also accuracy, integration, and caring comportment in VBSC practices could be valuable in future research to improve VBSC education.

**Implications for the future**

**Implication in nursing**

VBSC is a common procedure in nursing care. A fundamental responsibility for nurses is to alleviate suffering (25, 177). Repeated VBSC due to deficiencies in the organisation or suboptimal VBSC practices can be prevented. Training in work technique is important for safety and well-being
of patients (31, 182). Good practical skills in nursing that combine technical, theoretical, psychosocial and physical elements are therefore needed. Therefore, practical skills within nursing research must be worthy of interest (24). Using a model for practical skills in nursing to describe VBSC in a more holistic and less technical way might highlight VBSC as a practical nursing skill. Therefore, patient safety programs that minimise risk of harm to patients and providers through system effectiveness as well as individual practice are needed (34, 47, 56, 182).

**Implementation strategies to plan and develop educations**

Adoption of practice guidelines is affected by several issues, among them the way they are implemented (169, 173). High evidence that the context is accessible to change, as well as positive cultures (174), appropriate monitoring and feedback mechanisms (71), and available time for personnel to read and discuss research (163, 173) are mentioned as improving adoption of guidelines. The evidence level supporting the EIP evaluated in this thesis varied, as did the context and culture in the PHCs (128, 183). In light of this finding it is a challenge to implement changes in VBSC in healthcare to improve patient safety. Studies point out that use of implementation theories may identify implementation barriers beforehand (163, 184). In respect to our findings and also the challenge to change practical routines in healthcare we suggest the use of an implementation theory when implementing guidelines for VBSC practices. For a successful implementation of routines for adherence to VBSC guidelines, it is also important to take into consideration cognitive theories monitoring performance and providing feedback (73, 185, 186). It is important to study the implementation process as a whole in order to improve future interventions.

More specifically, for a successful implementation, conditions influencing improvements must be taken into account in order to speed up improvements in health care (186, 187). Also, it is necessary to create a culture in which the existence of risks is acknowledged (3, 41, 55, 57, 187) and to accept that most human mistakes are performed in relation to the system (51). Furthermore, it is essential to maintain a successful implementation, and maintenance of patient safety is a creative process. The use of multidisciplinary teams is one way to maintain an implementation procedure (9, 61) and is essential to enhance patient safety.
Monitoring of VBSC errors

To prevent diseases, screening programs are used, aimed at detecting early signs of the disease or condition (188). In comparison, monitoring high frequencies of near misses (Studies II and III), aimed at identifying potential errors, would improve the quality of VBSC practices more than merely focusing on assessment of underreported incidents or registered rare adverse errors. Monitoring for near misses makes it possible to prevent VBSC errors such as mismatching of patients (5, 51, 182). Before implementing a monitoring strategy it is important to determine whether the benefits outweigh the harms (152, 188). In this thesis, several benefits for the patient, such as less repeated sampling, correct treatment, and a decrease in diagnosis delay have already been described.

A tentative suggestion (Figure 5) for a national VBSC error-monitoring program is divided into three levels. Monitoring is performed simultaneously in all Swedish healthcare units. The validated VBSQ is used in a survey among VBSC personnel and laboratory records estimate the frequency of low-level haemolysis. The results of the VBSQ and the frequency of low-level haemolysed specimens lead to a decision as to which action to take, such as education or a directed intervention or both. Eventually, interviews could be used to identify deficiencies in the higher level of the system.

![Figure 5](image-url) A tentative suggestion of a monitoring program for preanalytical VBSC errors.

Continuous general large-scale VBSC education

According to the system perspective, the management should ensure that routines assure that the competence among healthcare personnel is maintained (9, 41). The EIP in this study was performed by laboratory instructors. Education was given at different times and mostly at the university hospital, which offered low flexibility for when to take part in the program. Despite difficulties in performing the EIP, conditions improvements were found. To develop an effective education, curriculum designers and instructors must be aware of appropriate pedagogical strategies (71). To ensure that every VBSC personnel member has the
opportunity to take part in the EIP, e-learning is a successful way to teach and has been shown to be as effective as a general educational program (189-191). Thus, a VBSC e-learning program could be appropriate for large organisations, and accessible to personnel in rural areas. E-learning gives flexible opportunities for the organisation as well as for the personnel; it is a cheap and a growing educational tool (189). The large-scale EIP could be transferred into an e-learning program and revised to include interactive meetings, reminders, discussions and exercises. Education via e-learning provides as good and possibly better, results among users as traditional education, including oral presentation (189).

**Directed VBSC education when needed**

In this thesis we evaluated a general EIP in the area of VBSC. However, a directed intervention probably would have improved sample quality even more. Another study showed that directed intervention involving individual phlebotomists succeeded in improving venous stasis use (192) by implementing CLSI H-03-A6 (11). If the aim of the EIP is to reduce repeated sampling due to sample rejection caused by haemolysis, directed interventions should focus on changes with high evidence. Thus, it is essential to perform VBSC by venepuncture, instead of using intravenous catheters (136, 138, 193), and drawing blood from antecubital fossa, instead of more distal sites (193). On the other hand, one must also consider that recommendations with less evidence should be implemented, such as using needles with large bore gauge >22 (124), and fully filling test tubes (124, 134), and that recommendations of a short time between sampling and analyses (134), conservative use of tourniquet (116, 124, 138), no delay in separation of blood from plasma (113), and assurance of muscle relaxation during sampling (13) should be included in the EIP. However, in developing direct interventions, it is important to decide where to put the cut-off for steps included in the EIP.

A general as well as a directed intervention can also include hands-on practice with subsequent reflection (194). That kind of directed education might decrease the frequency of haemolysed specimens and lead to less repeated sampling and more reliable test results further. The model of practical performance in nursing (26, 36, 194) might be a valuable reflection tool in interventions. To develop education that motivates reflection is considered as important in education. Reflection in relation to earlier experiences may lead to deeper learning in contrast to superficially memorising of facts (181).
Methodological discussion

Using triangulation to achieve trustworthiness in research provides a basis for convergence of the truth (144). We used triangulation in design, participants and subjects, data collection, and analytical techniques.

Strengths

A strength of this thesis was that the research was clinic-based and the EIP was developed out of the needs of the VBSC personnel.

In this thesis, we described the context, so that other researchers or nurses can decide whether they can apply our results in their contexts or carry out a similar study (159, 160). Our studies were performed in all PHCs in two county councils. Recruiting participants from two county councils, constituting the IG and the CG, respectively, reduced the risk of spillover effect (Study II).

We used the VBSQ, the HI, and interviews evaluating the large-scale EIP focusing on VBSC practices to answer the research aim. Those methods enable a broad range of preanalytical VBSC practices to be cross-checked (144, 147). Thus, we could study adherence to VBSC guidelines from different perspectives (147, 151). Studies II and III had a comparative before and after design. Comparing a group who had undergone an EIP with a CG who did not take part in the EIP produced good evidence based on the results (83).

The EIP comprised almost all VBSC personnel of VLL and thus included VBSC personnel in both hospital wards and primary healthcare. We limited our evaluation to the PHCs. However, the study population was clinically relevant, as the distribution of the participants’ professional status is typical of Swedish PHCs. Informants and blood specimens from PHCs in VLL and LVN were included. We also interviewed 30 VBSC personnel from ten PHCs, which provided a variety of the participants’ experiences.

When testing the VBSQ for validity and reliability the period between test and retest was three to four weeks. It was judged to be close enough that collection procedures and guidelines had not changed and long enough so the participants’ did not remembered how they answered at the first test (142). Further, the self-reported VBSQ demonstrated results similar to those in other observational studies (68, 146). That strengthened our VBSQ.
Monitoring low-level haemolysis is valuable in order to identifying poor VBSC practices. Monitoring HI also allowed a big sample as well as short- and long-term follow-ups. A perfect intervention should lead to short as well as long-term improvements (82). In Study III there were no differences between the short- or the long-term measurements (results not shown). The linear relationship between HI and free Hb ($R^2 = 0.986$) (158) showed validity for HI as a measurement. Thus, results (Study III) can be generalisable to other laboratories, if using the same test tube manufacturers and laboratory analysis instruments. Furthermore, all the interviews were conducted by the first author at the participants’ workplaces and with the same open-ended guide.

Teams of multiple individuals analysed and interpreted the data in all studies. Different statistics were used in the analytical process to achieve a strength in the analyses. In the interviews, two authors analysed five interviews independently, and all authors discussed and compared interpretations in an open dialogue continuously.

**Limitations**

Professions, qualifications, and work environment in the PHCs vary. As well, the counties within this thesis are affected daily by different influences which were difficult for us, as researchers, to control and may affect our results. However, the reason for the increased number of haemolysed specimens (Study III) is not known; the working conditions before and after the intervention were similar, and the result could not be explained by low participation. In PHC number 6, 100%, and in PHC number 7, 95%, of VBSC personnel took part in the educational intervention. Findings (Studies II and III) might also be affected by the previous questionnaire survey in 2007. PHCs with high frequencies of correct answers or high specimen quality at baseline had little room for positive change. An intervention improvement is expected when the starting point adherence to guidelines or blood specimen quality is low and vice versa.

There are some limitations in using self-reported questionnaires; one of them is the ability to remember (Study I); others are changes in knowledge and behaviour over time (Studies I and II) (142, 145).

Other circumstances that could have affected the outcome are personnel turnover, which was rather high after the intervention; the sample size; a small variation between the answers; and recall bias. There was also an imbalance between professional groups in the IG (Study II, Table 2) at
baseline, and more enrolled nurses were employed in the CG whereas more registered nurses were employed in the IG. No significant differences in self-reported answers regarding adherence to guidelines were found between those two professional groups.

The national guideline (13) as well as the EIP included information concerning other important topics that indirectly affect the sampling, which might have caused the reader to miss information in instructions. Guidelines and information in educational programs should be short and easy to understand (70). A weakness with the short EIP is that it contained no practical training or opportunities for deeper discussions. One third of the IG (Study II) performed the EIP through live Internet link, while the others had traditional lectures. However, no significant differences were found between those two groups in seven randomly selected items.
Conclusions

This thesis, as far as we know, is the first to evaluate the impact of a large-scale, preanalytical EIP aimed at improving VBSC practices. Self-reported VBSQs and monitoring of low-level haemolysis reflected VBSC practices and could be used to evaluate the EIP’s impact on VBSC practices. The high frequency of near-miss markers in contrast to low frequencies of reported adverse events makes it possible to compare and benchmark healthcare units and hospital wards. It was obvious that the EIP opened up opportunities for reflection on safety. The general EIP had an impact on several VBSC practices, while some VBSC practices remained unchanged. There are still several areas in VBSC practices that need improvement through further and continuous interventions, with the understanding that changes take time. In addition, EIPs providing time for reflection and discussion based on specific VBSC flaws may be effective. Findings could also be explained in large part from a system perspective, which indicates that some elements such as deficiencies in transfer of information, environmental disturbances, rest prior to sampling, and unclear guidelines must be changed on a level in the system other than an educational program for VBSC personnel on the frontline. Further research is needed to explore different PHC cultures and how different cultures influence VBSC practices.
Clinical implications

Our results demonstrate that an EIP improved VBSC practices indicating that monitoring and counteracting the near misses in VBSC is a well-functioning preventive action. The VBSQ can be used as a valuable instrument to develop the quality in healthcare worldwide. Also, employing low-level haemolysis to evaluate or benchmark VBSC practices in this systematic way can be recommended to other laboratories or healthcare units. Self-reported questionnaire surveys can also be compared with the haemolysis level of the corresponding healthcare unit. A VBSC educational intervention can update and sustain VBSC practices in healthcare. The general EIP can improve VBSC practices in PHCs with larger deviations from guidelines, while a directed educational program with increased focus on specific topics and including reflection and discussions is probably more effective than a general EIP when specific flaws are identified. Our studies have led to deeper and extended knowledge of the impact of an EIP on VBSC practices. Participants experienced that the EIP opened up opportunities for reflections on safety and described several additional risks during VBSC practices, such as transfer of information between occupations and units, and environmental disturbances. Our results can be used when considering future VBSC practice interventions. Using a model for practical skills in nursing to describe VBSC in a more holistic and less technical way might highlight VBSC as a practical nursing skill.
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Appendix
Questionnaire regarding blood-sampling practices at primary health care centres (PHCs)

(Please read the attached information letter before proceeding below)

Instructions for completing the questionnaire

This questionnaire contains questions concerning venous blood sampling for clinical chemistry analysis. You will be asked to complete a few yes/no questions. You will also be asked if you Never, Seldom, Often or Always carry out a task in a specific manner. It is important that you select the most suitable alternative from the choices given. This means that you should not mark an answer between two alternatives. In the final question we will ask for your opinion and suggestions.

Mark your answers by placing a cross in the box beside the most suitable alternative ✕
If you wish to change an answer, fill in the incorrectly marked box completely □

We are interested in how you carry out your daily work. If you are unsure of how to answer a question – answer how you usually do.

In questions like in the example below, it is IMPORTANT that you mark one alternative for EACH row.

Example of a correct answer:

Ⓐ Which utensil do you use for eating soup?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Seldom</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Fork</td>
<td>✕</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Spoon</td>
<td></td>
<td></td>
<td></td>
<td>✕</td>
</tr>
<tr>
<td>c) Knife</td>
<td></td>
<td></td>
<td>✕</td>
<td></td>
</tr>
</tbody>
</table>

Place the completed questionnaire in the enclosed envelope, seal it and give the envelope to the head of your PHC. We will collect the envelopes at the end of the survey period.

It is crucial that you answer the questions as honestly and carefully as possible. This means that you should answer how you usually perform a given task, not how you know that it is supposed to be done.
The following section contains questions regarding year of birth, education and routines

1 In which year were you born? 19 __ __

2 For how long have you been employed at this PHC? __ __ year __ __ month

3 How often do you carry out venous blood sampling?
   - Every workday □
   - Every week □
   - Every month □
   - More seldom □
   - Never □

4 Which year did you receive your most recent education in venous blood sampling? __ __ __ __

5 Which year did you before that, receive education for venous blood sampling? __ __ __ __

6 Do you want education in venous blood sampling? No □ Yes □

The following questions concern patient identification and collection of specimen

*It is important for you to mark ONE alternative for EACH row in the following section.*

7 How and how often do you check the identity of a patient when collecting venous blood samples?
   a) I ask the patient to state his/her name and social security number □ □ □ □ □
   b) I already know the patient and don’t have to check this □ □ □ □ □
   c) I ask the patient’s relatives □ □ □ □ □
   d) I check the patient’s photo-ID □ □ □ □ □
   e) By other means: ____________________________ □ □ □ □ □

8 If you use stasis when performing venous blood sampling, when do you remove it?
   a) Before the first sample is drawn □ □ □ □ □
   b) During sampling □ □ □ □ □
   c) When the sampling is finished □ □ □ □ □
   d) If there is difficulty collecting the sample, I keep the stasis as long as necessary □ □ □ □ □
9 How long do you usually allow your patient to rest (supine or sitting) prior to venous blood sampling?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>0-5 min</th>
<th>6-10 min</th>
<th>11-15 min</th>
<th>More then 15 min</th>
<th>I don't check this</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

10 How often do you carry out the following tasks?

a) If the test tube has an additive, invert the test tube several times immediately before the next one is filled?  
   Never □ □ □ □  Seldom □ □ □ □  Often □ □ □ □  Always □ □ □ □

b) Use an automatic test tube inverter  
   □ □ □ □ □ □ □ □

The following questions concern sample storage and seeking information

*It is important for you to mark ONE alternative for EACH row in the following section.*

11 What do you do when you are not sure of how a sample should be collected?

a) I check printed sampling instructions (available at the PHC) issued by the lab  
   Never □ □ □ □  Seldom □ □ □ □  Often □ □ □ □  Always □ □ □ □

b) I check sampling instructions on the lab homepage/on the internal network  
   □ □ □ □ □ □ □ □

c) I ask a colleague  
   □ □ □ □ □ □ □ □

d) I call the lab  
   □ □ □ □ □ □ □ □

e) By other way:..............................................................  
   □ □ □ □ □ □ □ □

12 How do you store the test tubes immediately after sampling?

a) Lying on a workbench or other similar location  
   Never □ □ □ □  Seldom □ □ □ □  Often □ □ □ □  Always □ □ □ □

b) In the pocket of my work wear  
   □ □ □ □ □ □ □ □

c) In a test tube stand  
   □ □ □ □ □ □ □ □

d) By other mean:..............................................................  
   □ □ □ □ □ □ □ □
The following questions ONLY concern sampling with paper based test requests

*It is important for you to mark ONE alternative for EACH row in the following section.*

13 How often does someone else mark the sampling time on the test request?

<table>
<thead>
<tr>
<th></th>
<th>Every day</th>
<th>Every week</th>
<th>Every month</th>
<th>More seldom</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14 When do you mark the sampling time on the test request, if you do it yourself?

<table>
<thead>
<tr>
<th>Marking Time</th>
<th>I never mark sampling time</th>
<th>More than 30 min before sampling</th>
<th>0-30 min before sampling</th>
<th>0-30 min after sampling</th>
<th>More than 30 min after sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15 How often do you perform the following tasks?

<table>
<thead>
<tr>
<th>Task</th>
<th>Never</th>
<th>Seldom</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Compare the patient’s name and social security number with the information on the test request</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Use test requests that somebody else has filled in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Sign the test request</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Check the information on the test request, if somebody else has completed it</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Adjust sampling time on the test request, if the marked time differ with more than 30 min from the actual sampling time?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Check that the test request and test tube identification (barcode) numbers match, before delivery to the laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16 When do you label the test tube?

<table>
<thead>
<tr>
<th>Labeling Time</th>
<th>Never</th>
<th>Seldom</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Before I approach the patient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Alongside the patient before sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Alongside the patient after sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) At a later occasion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Somebody else has labelled the test tube in advance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Somebody else labels the test tube after sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These final questions concern error reporting, ranking and suggestions

It is important that you to mark ONE alternative for EACH row in the following section.

17 Approximately, how many error reports have you written after observing or making an error in venous blood sampling?

<table>
<thead>
<tr>
<th>Number of times</th>
<th>Haven't written any</th>
</tr>
</thead>
<tbody>
<tr>
<td>_ _ times</td>
<td>□</td>
</tr>
</tbody>
</table>

18 If you have refrained from writing an error report: What was/were the reason/reasons?
(Please complete the questions below even if you have never written any report.)

a) I don’t have enough time
□ □ □ □

b) It wouldn’t make any difference
□ □ □ □

c) Nobody else does
□ □ □ □

d) It is too complicated
□ □ □ □

e) The head of the PHC writes the error reports
□ □ □ □

f) I am concerned about possible consequences
(specify below)
□ □ □ □

g) By other reason:………………………………………………
□ □ □ □

19 To what extent do you agree in the following statements?

a) I have enough knowledge for my daily work with respect to venous blood sampling and specimen handling

□ 

□

□

□

b) Proper collection and handling of venous blood samples is considered a priority at my PHC

□

□

□

Thank you for completing the questionnaire!

Please make sure that you have completed all questions, then place the questionnaire in the enclosed anonymous returning envelope, seal it, and give the envelope to the head of your PHC.