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Effectiveness of Nursing Interventions in Preventing Iatrogenic Anemia Associated with Frequent Blood Sampling in Hospitalized Patients

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ABSTRACT: Frequent phlebotomy in hospitalized patients—particularly in critical care settings—represents a significant yet often overlooked contributor to hospital-acquired anemia. Diagnostic blood loss accumulates rapidly when patients undergo multiple daily draws for laboratory monitoring, and this iatrogenic component can account for a substantial proportion of total red cell loss in patients already vulnerable to anemia from illness, surgery, or hemodilution. The clinical consequences are meaningful: increased transfusion requirements, prolonged length of stay, higher infection and mortality risk, and greater healthcare costs. Nurse-driven interventions targeting the modifiable nature of this blood loss—such as implementing blood conservation devices, consolidating laboratory orders, using pediatric or low-volume collection tubes, minimizing discard volumes from arterial and central lines, and applying evidence-based transfusion thresholds—have demonstrated measurable reductions in cumulative blood loss and transfusion rates. Educational programs and protocol-driven "blood stewardship" bundles that empower nursing staff to question unnecessary tests and coordinate sampling schedules have proven especially effective, as they address the behavioral and systems-level drivers of over-sampling rather than relying on individual clinician vigilance alone. Despite this evidence, adoption remains inconsistent, underscoring the need for standardized institutional policies, audit and feedback mechanisms, and interdisciplinary collaboration to sustain practice change and protect hematologic reserve in hospitalized patients.

INTRODUCTION

Iatrogenic anemia is a form of anemia that develops during hospitalization as a consequence of medical care rather than the patient's underlying disease. It is increasingly recognized as a measurable patient-safety problem, and systematic reviews of laboratory medicine practices have identified diagnostic blood loss as one of the few modifiable contributors to its development [1]. Hospital-acquired anemia is common in acutely ill patients and is associated with longer stays, greater transfusion exposure, and worse clinical outcomes; scoping reviews of diagnostic blood loss in critical care have therefore emphasized the need to separate unavoidable from avoidable blood loss and to target the latter through practice change [2]. The clinical importance of this problem is reinforced by narrative reviews arguing that hospital-acquired anemia should be treated as a preventable complication of care rather than an incidental laboratory finding [3]. Reviews focused specifically on the hazard of hospitalization have defined hospital-acquired anemia as a fall in hemoglobin during admission and have highlighted repeated phlebotomy as a major, potentially controllable cause [4].

The problem is not confined to adult intensive care. In pediatric intensive care, prospective cohort data have shown that diagnostic blood sampling is associated with anemia at discharge and that a substantial proportion of sampled blood is wasted through discard and over-collection [5]. In adult intensive care, the STRATUS randomized clinical trial tested small-volume blood collection tubes as a system-level strategy to reduce transfusion exposure, illustrating that the volume of blood drawn for testing can be modified without compromising laboratory information [6]. Systematic reviews of blood conservation practices in intensive care have concluded that closed sampling systems and conservative phlebotomy protocols can reduce sample volumes, although the quality and consistency of the evidence vary [7]. A broader scoping review across neonatal, pediatric, and adult populations found that bundled interventions including staff education and protocols reduced blood test frequency and volume, while small-volume tubes and blood conservation devices appeared effective in adults [8].

Defining and Measuring Iatrogenic Anemia

Iatrogenic anemia is best understood as anemia attributable to diagnostic or therapeutic procedures, with diagnostic phlebotomy being the most frequent and most preventable cause. Hospital-acquired anemia has been defined in the literature as a reduction in hemoglobin during hospitalization compared with the value on admission, regardless of preadmission levels, and it is commonly stratified by severity using hemoglobin thresholds [4]. This definition is useful because it captures the dynamic nature of hospital-associated hemoglobin decline and allows clinicians to distinguish patients who arrive anemic from those who become anemic during care. However, the definition also has limitations: hemodilution from fluid resuscitation, inflammation-associated suppression of erythropoiesis, nutritional deficiency, and occult bleeding can all contribute, so not every case of hospital-acquired anemia is purely iatrogenic [3]. For this reason, the most rigorous studies of blood sampling attempt to

quantify phlebotomy volume, discard volume, and the number of sampling episodes rather than relying only on hemoglobin change [2].

Measurement is central to nursing practice because what is not counted cannot be managed. Reviews of diagnostic blood loss recommend recording the volume drawn per test, the discard volume required to clear vascular access devices, the number of tests per patient-day, and the cumulative volume per admission [2]. The scoping review by Francois and colleagues further emphasizes that strategies to reduce diagnostic blood loss should be evaluated across neonatal, pediatric, and adult populations, because the same intervention may have different effects depending on total blood volume and physiological reserve [8]. In nursing terms, this means that quality improvement should include not only hemoglobin and transfusion outcomes but also process measures such as discard volume, tube size, and appropriateness of test ordering. Without such measures, hospitals may underestimate the magnitude of diagnostic blood loss and may fail to recognize successful nursing-led conservation efforts.

Mechanisms and Sources of Diagnostic Blood Loss

The mechanisms of phlebotomy-associated anemia are cumulative and often invisible in daily practice. The first source is the analytical volume required by the laboratory. The second is the discard volume needed to clear catheter dead space before a clean sample can be obtained; this volume can exceed the analytical volume, particularly when blood is drawn from arterial or central venous catheters [2]. The third source is over-collection in blood culture bottles and other collection systems. An educational study of medical personnel found that before a six-month intervention only 31% of aerobic and 34% of anaerobic blood culture bottles were filled correctly with 5–10 mL of blood, and that education increased correct filling to 43% while reducing mean sample volume, demonstrating that a meaningful proportion of diagnostic blood loss is related to technique and habit rather than to unavoidable testing requirements [9]. The fourth source is redundant testing, in which the same laboratory value is ordered repeatedly or by different teams without sharing results [2]. These sources interact: a patient with an arterial line may have frequent blood gas testing, each episode requiring discard volume, and may also have routine chemistry testing ordered by multiple services [10].

Vascular access is a particularly important nursing-relevant determinant of diagnostic blood loss. Central line access has been shown to be predictive of diagnostic blood loss and transfusion in surgical intensive care unit patients, with the presence and duration of a central venous catheter contributing to increased laboratory testing [10]. Research sampling itself has been identified as a source of iatrogenic anemia in critically ill patients, and monitoring research blood sampling has been proposed as a necessary ethical and clinical safeguard because research-related phlebotomy adds to clinical phlebotomy [11]. In neonatal intensive care, quality improvement projects have shown that a modified blood-sampling protocol can reduce the amount of blood sampled without negatively affecting neonatal outcomes, which is important because preterm infants have very small total blood volumes and limited capacity to replace lost erythrocytes [12]. These findings collectively show that diagnostic blood loss is not a single event but a series of modifiable nursing and systems decisions: which test to order, whether to use an existing line, how much discard volume to use, what tube size to select, and whether results are shared.

Clinical and Economic Consequences of Iatrogenic Anemia

The consequences of iatrogenic anemia extend beyond a laboratory abnormality. At the patient level, progressive anemia reduces oxygen-carrying capacity and may contribute to fatigue, tachycardia, dyspnea, impaired mobility, and delayed recovery [3]. At the level of clinical management, anemia is a common trigger for red blood cell transfusion, and transfusion itself carries risks of transfusion reactions, transfusion-associated circulatory overload, transfusion-related acute lung injury, immunomodulation, and increased resource use [4]. The economic dimension is also significant: transfusion is costly, blood components are scarce, and unnecessary transfusion exposes patients to avoidable risk while consuming finite health-system resources [4]. From a nursing perspective, these consequences matter because nurses are often the professionals who recognize early signs of anemia, prompt hemoglobin testing, and administer transfusions; nursing interventions that prevent diagnostic blood loss therefore have direct implications for patient comfort, safety, and resource stewardship.

Observational studies have strengthened the link between diagnostic phlebotomy and hospital-acquired anemia. In hospitalized patients, diagnostic blood testing has been shown to cause measurable falls in hemoglobin and hematocrit, supporting the argument that phlebotomy is not a benign intervention [13]. In patients with acute myocardial infarction, diagnostic blood loss from phlebotomy has been associated with hospital-acquired anemia, indicating that even patients with cardiac disease—who may be particularly vulnerable to anemia—are exposed to cumulative blood loss during routine care [14]. In cardiac surgical care, contemporary bloodletting for laboratory testing has been identified as a substantial contributor to postoperative anemia

and transfusion exposure, despite advances in surgical and perfusion techniques [15]. These findings are clinically important because cardiac and critically ill patients often have limited physiological reserve and are precisely the populations in whom unnecessary transfusion should be minimized. Nursing-led blood conservation therefore offers a way to reduce a modifiable exposure that sits at the intersection of patient safety, transfusion stewardship, and cost containment.

The Nursing Role in Blood Conservation

Nurses are central to blood conservation because they control the point of blood collection. In most hospitals, nurses perform or supervise bedside phlebotomy, manage arterial and central venous catheters, decide when to discard line contents, select collection tubes, label and send specimens, and communicate with laboratory and medical teams about duplicate testing [2]. This positioning gives nurses both responsibility and opportunity. Responsibility arises because small routine decisions—such as drawing an extra tube "just in case" or discarding a larger volume than necessary—can cumulatively harm patients. Opportunity arises because nurses can implement evidence-based practices at the bedside without waiting for large-scale organizational change [8]. The scoping review evidence suggests that nursing-sensitive interventions such as staff education, protocol use, small-volume tubes, closed sampling devices, and point-of-care testing can reduce diagnostic blood loss when implemented systematically [8].

The nursing role also includes advocacy for test stewardship. Because nurses often initiate or facilitate laboratory testing, they can question duplicate orders, encourage sharing of results between teams, and prompt clinicians to consider whether a test will change management [2]. Patient blood management frameworks provide a useful structure for this work. Patient blood management bundles emphasize minimizing phlebotomy volume and frequency, using blood-sparing techniques, and individualizing transfusion thresholds; these bundles are designed to facilitate implementation across disciplines and are well suited to nursing leadership [16]. The Frankfurt Consensus Conference recommendations on patient blood management further support a multidisciplinary approach that includes minimizing diagnostic blood loss and using restrictive transfusion strategies where appropriate [17]. Health-system-wide patient blood management programs have been associated with improved outcomes and reduced costs, demonstrating that coordinated conservation efforts can be scaled beyond individual units [18]. Nursing interventions for iatrogenic anemia are therefore not isolated technical fixes; they are part of a broader culture of patient blood management.

Closed Blood Sampling Devices

Closed blood sampling devices are among the most direct technological solutions to diagnostic blood loss. These systems allow the clearing volume to be returned to the patient rather than discarded, thereby eliminating or reducing the discard volume required before a clean sample is obtained [7]. In principle, this is attractive because it addresses a source of blood loss that is purely procedural and has no diagnostic value. Systematic reviews of blood conservation practices in intensive care have found that closed-loop systems can reduce blood sampling volumes and may reduce transfusion use, although the evidence base is limited by small trials and heterogeneous designs [7]. The STRATUS trial is relevant here because it tested a system-level change in collection tubes rather than an individual practitioner behavior, showing that the physical tools of sampling can be redesigned to reduce transfusion exposure [6].

For nursing practice, closed sampling devices have practical advantages and disadvantages. The advantage is that they can be integrated into existing arterial or central venous catheter workflows and can reduce the ethical discomfort of discarding patient blood [7]. The disadvantage is that they require initial training, purchasing decisions, and compatibility with existing catheter systems; without organizational support, nurses may be unable to adopt them even when evidence supports their use [8]. The scoping review by Francois and colleagues found that blood conservation devices and smaller tubes appear effective in adults, but implementation depends on contextual factors such as laboratory workflows and staff education [8]. Closed systems should therefore be viewed as one component of a nursing-led bundle rather than as a stand-alone solution.

Small-Volume Collection Tubes

Small-volume collection tubes reduce the analytical blood volume required per test and are one of the most widely studied blood conservation strategies. The STRATUS randomized clinical trial compared standard-volume with small-volume blood collection tubes in intensive care and evaluated whether this change reduced anemia and red blood cell transfusion; the trial is important because it moved the question from individual practitioner behavior to a system-level supply decision [6]. The scoping review evidence similarly indicates that small-volume tubes can reduce blood loss and transfusion in adults, although the

strength of evidence varies across settings [8]. The advantage of small-volume tubes is that they do not require nurses to change their bedside technique dramatically; the change is largely a matter of procurement, stock management, and laboratory acceptance [8]. This makes them attractive for nursing implementation because they reduce reliance on individual memory and vigilance.

However, small-volume tubes are not a complete solution. If the number of tests remains high, cumulative volume can still be significant; if laboratory analyzers require larger dead volumes or if tubes are incompatible with existing automation, the intended benefit may be lost [8]. In pediatric and neonatal settings, small-volume tubes are particularly important because total blood volume is low, but the range of available tube sizes and the need for adequate specimen volume for reliable analysis must be balanced [12]. Nursing involvement in product selection, stock placement, and education is therefore essential. Small-volume tubes work best when nurses understand why they are being used, when they are the default option, and when test ordering is simultaneously reviewed for appropriateness [8]. In this sense, small-volume tubes are a technical enabler of a broader nursing-led stewardship culture.

Reducing Sampling Frequency and Test Stewardship

Reducing the frequency of blood sampling is perhaps the most conceptually simple but practically challenging nursing intervention. Every blood draw has a cumulative cost, and reducing unnecessary tests directly reduces phlebotomy volume, discard volume, patient discomfort, and risk of anemia [2]. Test stewardship involves asking whether a test will change clinical management, whether the same information is already available, whether results can be shared across teams, and whether a less invasive or lower-volume alternative exists [2]. In critical care, where arterial lines and central catheters facilitate frequent sampling, the default may be to draw blood whenever a test is ordered rather than to question whether the test is needed [10]. Nursing advocacy for stewardship can interrupt this default and prevent "routine" testing from becoming a source of harm.

The evidence for conservative phlebotomy protocols is supportive but not uniform. Systematic reviews of blood conservation practices in intensive care have found that conservative phlebotomy protocols and closed-loop systems can reduce blood sample volumes, although studies have not consistently reported significant changes in hemoglobin [7]. The broader scoping review found that bundled interventions including protocols and education reduced blood test frequency and volume in both adults and children, suggesting that stewardship is most effective when it is embedded in a structured program rather than left to individual discretion [8]. For nurses, this means that test stewardship should be supported by unit protocols, daily review of laboratory orders, interdisciplinary rounds, and feedback on phlebotomy volumes. Without such supports, even motivated nurses may find it difficult to change long-standing routines.

Point-of-Care Testing

Point-of-care testing offers a way to obtain clinically useful information with smaller blood volumes and faster turnaround, potentially reducing the need for conventional laboratory testing and the associated phlebotomy volume [8]. In neonatal intensive care, quality improvement work has shown that a modified blood-sampling protocol can reduce iatrogenic blood loss without negatively affecting outcomes, and point-of-care devices are often part of such protocols because they allow bedside assessment with capillary or very small venous samples [12]. The scoping review evidence suggests that point-of-care testing, alone or bundled with other strategies, is promising for reducing diagnostic blood loss in adults and children [8]. For nursing practice, point-of-care testing can be empowering because it places results at the bedside and allows nurses to participate more actively in clinical decision-making.

Nevertheless, point-of-care testing is not automatically blood-sparing. If point-of-care tests are added to, rather than substituted for, laboratory tests, total blood loss may increase. The key nursing and organizational task is substitution: using point-of-care results to replace, not duplicate, conventional testing [8]. Quality assurance, device maintenance, training, and documentation are also essential to ensure that point-of-care results are reliable and that the blood-saving benefit is real. In settings where laboratory access is limited or turnaround times are long, point-of-care testing may have additional advantages for timeliness of care. As with other interventions, the greatest benefit is likely when point-of-care testing is integrated into a bundled blood conservation protocol rather than adopted as a standalone technology.

Education and Competency

Education is a foundational nursing intervention because many sources of diagnostic blood loss are related to knowledge, technique, and habit. The blood culture filling study described earlier showed that a six-month educational intervention—

including lectures, handouts, emails, and posters—improved correct filling of blood culture bottles and reduced mean sample volume, demonstrating that education can change measurable sampling behavior [9]. Education is particularly important for blood cultures because over-filled bottles waste blood and under-filled bottles can reduce diagnostic yield; nurses therefore need clear, practical guidance on appropriate fill volumes [9]. Education should also cover discard volume, catheter dead space, tube selection, and the rationale for test stewardship, because these are the decisions nurses make at the bedside [2].

Education alone, however, is insufficient. The scoping review evidence indicates that education is most effective when combined with protocols, feedback, and organizational supports [8]. Competency assessment should therefore include not only knowledge but also observed practice: how much discard volume is used, whether the smallest appropriate tube is selected, whether duplicate tests are questioned, and whether results are shared. Nursing educators can use audit and feedback to reinforce good practice and to identify units where blood conservation is not yet embedded. Education should also target interdisciplinary teams, because test ordering is often a medical decision and nurses need clinician support to reduce unnecessary testing [2]. A culture of blood conservation requires that education be continuous, practical, and linked to visible outcomes such as phlebotomy volume per patient-day and transfusion rates.

Bundled Interventions and Protocols

The strongest evidence supports bundled interventions rather than single measures. The scoping review by Francois and colleagues found that bundles including staff education and protocols reduced blood test frequency and volume in adults and children, and that blood conservation devices and smaller tubes appeared effective in adults [8]. This finding is consistent with the broader implementation literature: complex clinical behaviors are more likely to change when multiple barriers are addressed simultaneously through education, tools, reminders, and policy [16]. A nursing-led blood conservation bundle might include small-volume tubes as the default, closed sampling devices for arterial and central lines, a discard-volume policy, point-of-care testing where appropriate, daily review of laboratory orders, and feedback on phlebotomy volumes. Such a bundle addresses the technical, behavioral, and organizational determinants of diagnostic blood loss.

Patient blood management bundles provide a ready-made framework for this work. Hofmann and colleagues described patient blood management bundles to facilitate implementation, emphasizing that blood conservation requires coordinated action across disciplines and that bundle elements should be measurable and auditable [16]. The Frankfurt Consensus Conference recommendations support minimizing diagnostic blood loss as part of comprehensive patient blood management [17]. Health-system-wide programs have shown that coordinated patient blood management can improve outcomes and reduce costs, suggesting that nursing-led blood conservation can be part of a larger value-based care strategy [18]. For nursing leaders, the practical implication is that blood conservation should be written into unit protocols, orientation programs, competency checklists, and quality dashboards. When blood-sparing practices are the default and are visibly monitored, they are more likely to be sustained.

Table 1. Nursing Interventions for Preventing Iatrogenic Anemia and Reported Effectiveness

Intervention	Nursing action	Reported effectiveness	References
Closed blood sampling devices	Return clearing volume instead of discarding	Reduce discard-related blood loss and may reduce transfusion use in intensive care	[7], [8]
Small-volume collection tubes	Make small-volume tubes the default for appropriate tests	Reduce analytical blood volume and may reduce transfusion exposure; best used as part of a bundle	[6], [8]
Reduced sampling frequency and test stewardship	Question duplicate or unnecessary tests; share results	Reduces phlebotomy episodes and cumulative volume when supported by protocols	[2], [7], [8]
Point-of-care testing	Substitute bedside testing for selected laboratory tests	Promising for reducing diagnostic blood loss when used as substitution rather than addition	[8], [12]

Education and competency	Teach discard volume, tube selection, blood culture filling, and stewardship	Improves filling accuracy and reduces sample volume; stronger when combined with feedback	[9]
Bundled protocols	Combine education, tools, audit, and order review	Reduced blood test frequency and volume in adult and pediatric studies	[8], [16]

Special Considerations in Pediatric and Neonatal Populations

Pediatric and neonatal patients require special attention because their total blood volume is small and their tolerance for cumulative blood loss is limited. In the pediatric intensive care unit, prospective cohort data have shown that diagnostic blood sampling is associated with anemia at discharge and that a substantial proportion of sampled blood is wasted [5]. This finding is particularly concerning because children who survive critical illness may leave hospital with anemia that affects recovery, energy, and neurodevelopment. Neonatal intensive care presents an even greater challenge because preterm infants may have a total blood volume of less than 100 mL, so even small absolute volumes can represent a large proportion of circulating blood [12]. Quality improvement projects in neonatal units have demonstrated that modified blood-sampling protocols can reduce iatrogenic blood loss without negatively affecting neonatal outcomes, providing a model for nursing-led change [12].

The scoping review by Francois and colleagues explicitly included neonatal and pediatric populations and found that small-volume tubes and bundled interventions may reduce blood loss and transfusion in these groups, although the evidence base is smaller than in adults [8]. For nurses caring for children and neonates, key practices include using the smallest appropriate tube, minimizing discard volume, avoiding unnecessary tests, coordinating sampling times to reduce repeated needle sticks, and using point-of-care testing when validated for the population [8], [12]. Parents and caregivers should also be engaged, because repeated blood sampling is distressing for families and can erode trust. Nursing communication about why a test is needed, how much blood will be taken, and what alternatives exist is part of ethical, family-centered care. In these populations, the margin for error is small, so blood conservation should be treated as a core safety practice rather than an optional efficiency measure.

Barriers to Implementation

Despite supportive evidence, implementation of blood conservation interventions is inconsistent. Barriers include lack of knowledge, competing clinical priorities, difficulty changing established routines, concerns about specimen adequacy, laboratory automation constraints, cost and procurement issues, and weak interdisciplinary communication [8]. The scoping review evidence notes that although small-volume tubes and blood conservation devices appear effective, their implementation depends on contextual factors such as laboratory workflows and staff education [8]. Patient blood management implementation more broadly faces challenges related to hospital culture, staff time, interdisciplinary collaboration, change management, and documentation [16]. These barriers are not unique to blood conservation, but they are particularly important because diagnostic blood loss is often invisible and cumulative; no single blood draw appears harmful, so the motivation to change may be low until the cumulative effect is recognized.

Nursing-specific barriers include heavy workloads, high staff turnover, reliance on agency or float staff, and the perception that phlebotomy is a technical task rather than a patient-safety intervention [2]. If blood conservation is not included in orientation, competency assessment, and quality indicators, it may be deprioritized when units are busy. Interdisciplinary barriers include disagreement about who is responsible for test stewardship and concern that reducing testing may delay diagnosis [8]. These barriers can be addressed through visible leadership support, clear protocols, audit and feedback, and inclusion of nursing staff in product selection and policy development. The evidence suggests that bundled interventions are more likely to overcome barriers than single-component interventions, because they change the default rather than relying on individual vigilance [8], [16].

Table 2. Barriers and Enablers to Nursing-Led Blood Conservation

Domain	Barrier	Enabler
Knowledge	Uncertainty about discard volume, tube size, or test necessity	Education, competency checklists, quick-reference guides [9]

Behavior	Routine and habit; "just in case" sampling	Default small-volume tubes, closed systems, reminders [6], [7]
Interdisciplinary	Unclear responsibility for test stewardship	Daily rounds, shared results, agreed protocols [2], [8]
Organization	Cost, procurement, laboratory automation constraints	Leadership support, business case, pilot evaluation [8], [16]
Culture	Invisibility of cumulative blood loss	Audit and feedback, dashboards, patient stories [8]

Monitoring, Audit, and Nursing Quality Indicators

Monitoring is essential for sustaining nursing-led blood conservation. Useful process indicators include phlebotomy volume per patient-day, discard volume per sample, proportion of tests performed with small-volume tubes, proportion of blood cultures correctly filled, number of laboratory tests per patient-day, and proportion of duplicate tests. Outcome indicators include hemoglobin change during admission, transfusion rate, and hospital-acquired anemia incidence [2], [8]. These indicators can be incorporated into nursing dashboards and unit quality meetings. The monitoring of research blood sampling in critically ill patients provides a useful precedent: research sampling should be counted and justified, and the same logic can be applied to clinical sampling [11]. In neonatal units, quality improvement projects have shown that protocol changes can be monitored through blood sampling volume and anemia outcomes, demonstrating feasibility even in high-acuity settings [12].

Audit and feedback should be non-punitive and focused on systems rather than individuals. Nurses are more likely to engage with blood conservation if they can see that their efforts reduce patient discomfort, transfusion exposure, and workload associated with repeat sampling. Unit champions can model good practice, and interdisciplinary review can identify tests that are frequently ordered without clear indication. The scoping review evidence supports bundled interventions that include protocols and education, and monitoring is a natural component of such bundles because it makes the problem visible [8]. Without monitoring, blood conservation may be adopted temporarily and then abandoned when attention shifts. With monitoring, it becomes part of routine quality improvement and can be sustained across staff changes.

Table 3. Suggested Nursing Quality Indicators for Blood Conservation

Indicator	Type	Rationale
Phlebotomy volume per patient-day	Process	Direct measure of diagnostic blood loss [2]
Discard volume per sample	Process	Targets a major modifiable source of loss [7]
Small-volume tube use rate	Process	Measures adoption of a system-level intervention [6]
Blood culture fill accuracy	Process	Reduces waste and improves diagnostic yield [9]
Duplicate test rate	Process	Reflects test stewardship [8]
Hospital-acquired anemia incidence	Outcome	Captures cumulative effect on patients [4]
Transfusion rate	Outcome	Reflects clinical and resource consequences [6]

Future Directions and Research Gaps

Several research gaps remain. First, although small-volume tubes and closed sampling devices have supportive evidence, there is a need for implementation studies that evaluate how these tools are adopted, sustained, and scaled in real-world nursing workflows [8]. Second, cost-effectiveness studies are needed to help hospital leaders decide which interventions to prioritize, particularly when laboratory automation and procurement contracts constrain choices [8]. Third, pediatric and neonatal evidence remains thinner than adult evidence, and age-specific protocols are needed [5], [12]. Fourth, patient-reported outcomes such as comfort, sleep disruption, and family experience of repeated blood sampling are understudied. Fifth, the interaction between diagnostic blood loss and other causes of hospital-acquired anemia—such as inflammation, fluid resuscitation, and occult bleeding—requires integrated models so that nursing interventions are appropriately targeted [3].

Future nursing research should use implementation science frameworks to test strategies such as audit and feedback, clinical decision support, nurse-led order review, and interdisciplinary blood conservation rounds. Studies should measure both process and outcome indicators and should include qualitative work on barriers and enablers from the nursing perspective. The scoping review by Francois and colleagues provides a useful map of the evidence, but it also highlights the need for rigorous, context-sensitive studies that go beyond efficacy to address sustainability [8]. Given that blood conservation is a low-risk, patient-centered intervention, the ethical case for further research and quality improvement is strong. Nurses should be partners in designing and leading this research, because they are closest to the clinical problem and are most likely to implement the solutions.

CONCLUSION

Iatrogenic anemia due to frequent blood sampling is a prevalent and preventable issue in hospitals, stemming from factors such as excess analytical and discard volumes, duplicate tests, and routine sampling practices. This condition leads to significant clinical and economic consequences, including symptoms of anemia, increased transfusions, longer hospital stays, and higher resource utilization. Nurses play a critical role in mitigating this risk through their control of blood collection processes and test management. No single intervention suffices; solutions include closed blood sampling devices, small-volume tubes, reduced sampling frequency, point-of-care testing, and educational initiatives. However, implementation faces challenges such as knowledge gaps and institutional routines, which can be addressed through leadership support, education, and monitoring. Recognition of anemia as a significant public health issue underscores the importance of nursing interventions in blood management as a standard aspect of safe hospital care.

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