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Bridging the Gap: A Systematic Review of Nursing-Led Quality Assurance in Point-of-Care Testing (POCT) and the Integration of Laboratory Excellence at the Bedside

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ABSTRACT

Point-of-care testing (POCT) has revolutionized the clinical landscape by shifting diagnostic capabilities from centralized laboratories directly to the patient's bedside. This narrative review aims to examine the current state of nursing-led quality assurance in POCT and explore the critical integration of laboratory excellence into clinical practice. Utilizing a narrative review design, the study synthesizes current literature to identify the barriers, enablers, and technological advancements shaping the field. Major results indicate that while POCT significantly improves clinical decision-making and patient outcomes—particularly in emergency and acute care settings—challenges regarding operator competency, device maintenance, and data integration persist. The findings highlight that successful POCT implementation relies heavily on multi-specialty collaboration between nursing staff and laboratory professionals to ensure diagnostic accuracy. Major recommendations include the adoption of standardized training protocols, the integration of artificial intelligence (AI) and machine learning to minimize human error, and the implementation of robust digital frameworks for real-time data monitoring. Ultimately, the review concludes that bridging the gap between clinical nursing and laboratory science is essential for maintaining high-quality care. The implications of this study suggest that healthcare institutions must prioritize interdisciplinary governance and technological investment to safeguard patient safety and optimize the efficiency of bedside diagnostics.

Keywords: Point-of-Care Testing; Nursing-Led Quality Assurance; Laboratory Excellence; Bedside Diagnostics; Interdisciplinary Collaboration; Patient Safety

Abbreviations: POCT: Point-of-Care Testing; ISO: International Organization for Standardization; IQC: Internal Quality Control; EQA: External Quality Assessment; TAT: Turnaround Time; AI: Artificial Intelligence; ML: Machine Learning; QC: Quality Control

Introduction

The evolution of modern healthcare is increasingly defined by the demand for rapid, accurate, and accessible diagnostic information. Point-of-care testing (POCT) represents a paradigm shift in this direction, moving the diagnostic process from traditional, centralized laboratory environments to the immediate vicinity of the patient [1]. This transition is driven by the clinical need for "real-time" results that can immediately influence therapeutic interventions [2]. In acute and primary care settings, the ability to obtain instant data on glucose levels, blood gases, or cardiac biomarkers is no longer a luxury but a fundamental component of efficient patient management [3]. However, as testing moves closer to the bedside, the responsibility for quality assurance shifts from laboratory specialists to frontline nursing staff [4]. This shift necessitates a rigorous examination of how nursing-led quality assurance can maintain the high standards of laboratory excellence required for safe clinical practice [5]. The integration of POCT into healthcare systems globally has been characterized by both immense potential and significant logistical challenges. In Europe and beyond, the state of POCT reflects a growing reliance on decentralized testing to alleviate the burden on hospital infrastructure [2]. The benefits are clear: reduced turnaround times (TAT), shorter hospital stays, and improved patient satisfaction [6].

Yet, the decentralization of testing also introduces variables that are less controlled than those in a regulated laboratory setting [1]. For instance, environmental factors at the bedside and the diverse skill levels of non-laboratory operators can introduce pre-analytical and analytical errors [5]. Therefore, ensuring that bedside testing matches the "gold standard" of the central lab requires a robust framework of quality control and interdisciplinary oversight [4]. The technological landscape of POCT is currently undergoing a rapid transformation, with innovations such as electrochemical biosensors and portable mass spectrometry redefining the limits of bedside diagnostics [7,8]. These advanced systems allow for the detection of complex analytes, such as pathogenic bacteria in battlefield injuries or specific environmental toxins like 6PPD-quinone, using 3D-printed portable devices [9,10]. Furthermore, the application of ratiometric fluorescence probes and organic framework-based sensors has enhanced the sensitivity and specificity of these tools [10,11]. As these technologies become more sophisticated, the role of the nurse expands from a simple operator to a critical link in the diagnostic chain [12]. This expansion of responsibility requires nursing professionals to be adept not only in clinical assessment but also in the technical nuances of device management [13].

Central to the success of POCT is the concept of "Laboratory Excellence at the Bedside." This involves the application of rigorous laboratory principles—such as calibration, proficiency testing, and preventive maintenance—within the clinical workflow [5]. The integration of multiple specialties, including laboratory services, nursing, and rehabilitation, is vital for improving integrated patient management [4]. For example, in the management of hepatitis B, fingerstick blood POCT for DNA testing has been shown to enhance treatment decision-making, provided that the accuracy of the test is maintained through strict quality protocols [14]. Similarly, the use of multiorgan point-of-care ultrasound (POCUS) in critically ill adults demonstrates how advanced diagnostic tools, when led by trained clinicians, can provide life-saving insights [15]. These examples underscore the necessity of a unified approach where the laboratory provides the technical foundation and nursing provides the clinical execution [4]. However, the rapid adoption of POCT has also revealed gaps in standardization and governance. Many healthcare facilities struggle with fragmented systems where bedside data is not effectively integrated into the Electronic Health Record (EHR) [1]. This lack of connectivity can lead to "information silos," where critical results are known at the bedside but not documented or reviewed by the broader care team [5].

To address these gaps, emerging technologies such as artificial intelligence (AI) and machine learning (ML) are being leveraged to automate quality control and provide decision support [16,17]. AI-driven systems can help identify patterns of error and ensure that testing is performed within validated parameters, thereby bridging the gap between nursing practice and laboratory rigor [17]. In the context of infectious diseases, the COVID-19 pandemic served as a massive catalyst for the advancement of POCT, highlighting the need for rapid respiratory virus detection [18,19]. The lessons learned during the pandemic have accelerated the development of non-enzymatic electrochemical sensors and other robust platforms that can function in diverse environments [20]. These advancements, however, must be balanced with evidence-based frameworks to prevent issues like material-induced drug loss during therapy or other clinical errors [13]. The safety of the patient remains the paramount concern, and this can only be guaranteed if nursing-led POCT is supported by a culture of laboratory excellence [5]. Despite the proliferation of literature on specific POCT technologies, there is a need for a comprehensive synthesis that specifically addresses the intersection of nursing leadership and laboratory quality assurance.

Most existing reviews focus either on the technical specifications of devices or the clinical utility of specific tests. There is a noticeable lack of focus on the organizational and interdisciplinary frameworks required to "bridge the gap" between the two fields [4]. This review seeks to fill that void by examining the synergistic relationship between nursing-led clinical assessment and laboratory-led diagnostic indicators [12]. The purpose of this systematic review is to evaluate the current frameworks for nursing-led quality assurance in POCT and to identify the best practices for integrating laboratory excellence at the bedside.

Statement of the Problem

The proliferation of Point-of-Care Testing (POCT) has fundamentally altered the delivery of healthcare, yet it has introduced a signifi-

cant "quality gap" between decentralized testing and traditional laboratory standards [1]. While the primary goal of POCT is to improve patient outcomes through rapid diagnostics, the lack of standardized nursing-led quality assurance protocols often compromises the integrity of the results [5]. This problem is exacerbated by the fact that nursing staff, who are primarily trained in patient care, are increasingly tasked with complex laboratory functions without sufficient technical oversight [4]. Consequently, the potential for pre-analytical and analytical errors increases, posing a direct threat to patient safety [2]. A critical issue identified in the literature is the inconsistency in training and competency assessment for bedside operators [6]. Unlike laboratory personnel, whose primary role is diagnostic precision, nurses must balance POCT with multifaceted clinical responsibilities [13]. This dual burden can lead to the neglect of essential quality control (QC) procedures, such as device calibration and the documentation of reagent lot numbers [5]. Research indicates that in many settings, the enablers of POCT—such as speed and convenience—are overshadowed by drawbacks like inadequate troubleshooting and equipment failure [6].

Without a robust framework that bridges the gap between nursing practice and laboratory excellence, the reliability of bedside data remains questionable [12]. Furthermore, the integration of advanced POCT technologies, such as portable mass spectrometry and AI-driven biosensors, adds a layer of complexity that current clinical protocols are often unprepared to handle [8,17]. The transition from simple glucose monitoring to the detection of infectious pathogens or sepsis biomarkers requires a higher level of technical sophistication [9,12]. There is a documented disconnect between the rapid pace of technological innovation and the development of evidence-based nursing frameworks to manage these tools safely [13,20]. This disconnect is particularly evident in the lack of seamless data integration into Electronic Health Records, which leads to fragmented patient management [1]. The organizational silos between laboratory services and nursing departments represent a significant barrier to excellence [4]. Often, laboratory professionals view POCT as a risk to diagnostic standards, while nurses view laboratory requirements as an administrative burden [5]. This lack of collaboration results in poor governance and a lack of accountability for POCT outcomes [4].

In the absence of a unified strategy, the implementation of POCT remains ad-hoc and inefficient [3]. Therefore, there is an urgent need to synthesize current evidence to create a pathway for nursing-led quality assurance that harmonizes with laboratory standards. This review addresses this critical gap by exploring how interdisciplinary excellence can be achieved at the bedside to ensure diagnostic accuracy and patient safety.

Research Objectives

This review seeks to achieve the following objectives:

1. To evaluate the existing barriers and enablers of nursing-led quality assurance in Point-of-Care Testing (POCT) across various clinical settings.
2. To examine the impact of laboratory-nursing collaboration on the accuracy of bedside diagnostic indicators and integrated patient management.
3. To identify the role of emerging technologies, such as AI and advanced biosensors, in enhancing the reliability and monitoring of POCT results.

Literature Review

The paradigm of Point-of-Care Testing (POCT) is built upon the principle of bringing the laboratory to the patient to facilitate immediate clinical decisions [1]. At its core, POCT is defined by the rapid generation of results outside the physical walls of a central laboratory, often performed by non-laboratory personnel such as nurses, physicians, or paramedics [2]. The theoretical foundation for POCT integration often revolves around the "Value-Based Healthcare" model, where the reduction in turnaround time (TAT) is expected to translate into improved clinical outcomes and operational efficiency [1]. However, as scholars like [5] argue, this value is only realized if the quality of the result is equivalent to that of the central laboratory. This necessitates a framework where nursing leadership and laboratory excellence are not mutually exclusive but are deeply integrated [4].

The Role of Nursing in POCT Quality Assurance

Nurses are the primary operators of POCT devices in most hospital settings, making them the stewards of bedside diagnostic quality [12]. The integration of nursing-led clinical assessment with laboratory diagnostic indicators is particularly crucial in high-stakes environments like sepsis detection [12]. In such cases, the nurse's ability to interpret POCT biomarkers alongside physical symptoms can lead to significantly earlier interventions [12]. However, the literature emphasizes that for nurses to lead quality assurance effectively, they must be supported by evidence-based frameworks, such as the Selwan Sorption-Safe framework, which helps prevent clinical errors related to therapy [13]. The challenge remains that nursing curricula often lack depth in laboratory science, creating a gap in the understanding of analytical variability [5].

Laboratory Excellence and Interdisciplinary Collaboration

The concept of laboratory excellence at the bedside involves extending the rigorous standards of the International Organization for Standardization (ISO) to the clinical unit [1]. This includes strict adherence to internal quality control (IQC) and external quality assessment (EQA) [5]. Research indicates that when laboratory services and nursing care collaborate, there is a marked improvement in integrated patient management [4]. For instance, multi-specialty collaboration ensures that POCT devices are appropriately selected, validated,

and maintained [4]. Scholars have noted that the "laboratory-led, nursing-performed" model is the most effective way to ensure that the technical integrity of the test is maintained without compromising the speed of delivery [1].

Technological Innovations in Bedside Testing

Recent advances in biosensor technology have dramatically expanded the scope of POCT. Electrochemical biosensors and ratio metric fluorescence probes are now capable of high-sensitivity detection that was previously only possible in specialized labs [7,10]. The development of portable mass spectrometry systems has further pushed the boundaries, allowing for complex chemical analysis at the site of care [8]. Furthermore, the use of organic frameworks in electrochemiluminescence sensors has improved the detection of specific biomarkers, making them more resilient to the "noise" of bedside environments [11]. These technological leaps, including 3D-printing for portable devices, have made POCT more versatile, even in extreme conditions like battlefield injuries [9,10].

The Integration of AI and Machine Learning

The future of POCT is inextricably linked to the rise of artificial intelligence (AI) and machine learning (ML). These technologies offer solutions to the persistent problem of human error in bedside testing [17]. AI can automate the interpretation of complex results, such as those from multiorgan ultrasound, and provide real-time alerts for critical values [15,16]. Moreover, machine learning algorithms can analyze vast amounts of POCT data to identify trends that might be missed by human operators, such as subtle shifts in device performance or early signs of patient deterioration [16]. This "intelligent" POCT environment helps bridge the gap between nursing staff and the lab by providing an automated layer of quality assurance [17].

Challenges and Barriers to Implementation

Despite the technological progress, significant barriers remain. A survey of general practice services highlighted that while the benefits of POCT are recognized, drawbacks such as the cost of consumables, lack of connectivity, and the need for constant staff retraining are major hurdles [6]. In many cases, the "state-of-the-art" technology is present, but the organizational structure to support it is not [1]. There are also concerns regarding the use of non-enzymatic electrochemical sensors and their long-term stability in clinical settings [20]. The successful integration of POCT for viruses like COVID-19 or Hepatitis B DNA requires not just the device, but a comprehensive diagnostic accuracy study and a clear clinical pathway [14,18]. Without these, POCT can lead to "information overload" without clear clinical utility [3].

Results

Barriers and Enablers of Nursing-Led Quality Assurance

The review of literature reveals that the primary enablers of nursing-led POCT are the immediate availability of results and the empowerment of nurses to make rapid clinical decisions [3]. In acute care, the ability to monitor biomarkers at the bedside significantly enhances the speed of triage and treatment [12]. However, these enablers are frequently countered by significant barriers, including a lack of time due to high patient loads, which leads to the omission of quality control steps [6]. Furthermore, the lack of standardized training across different departments creates variability in how quality assurance is practiced [5]. Many nurses perceive laboratory quality protocols as rigid and difficult to integrate into a fluid clinical workflow, which remains a primary barrier to "laboratory excellence" at the bedside [4].

The Impact of Laboratory-Nursing Collaboration

The results consistently show that integrated management, characterized by active collaboration between laboratory services and nursing, leads to superior patient outcomes [4]. When laboratory professionals take an active role in training and overseeing POCT, the incidence of analytical errors decreases [5]. For example, in the detection of Hepatitis B DNA or respiratory viruses, collaborative protocols ensure that fingerstick testing meets the diagnostic accuracy required for treatment decisions [14,19]. The "silo" effect—where nursing and laboratory departments operate independently—was found to be the leading cause of "lost" results and poor device maintenance [1]. Conversely, an interdisciplinary approach ensures that POCT is used as an extension of the laboratory, maintaining high standards of excellence [4].

The Role of Emerging Technologies in Reliability

Emerging technologies have significantly increased the reliability of POCT by minimizing the potential for human error. The integration of AI and machine learning provides a "digital safety net," offering real-time feedback to operators and ensuring that tests are performed correctly [16,17]. Advanced sensors, such as those based on organic frameworks and non-enzymatic electrochemical designs, have shown improved durability and sensitivity, making them more suitable for the unpredictable bedside environment [11,20]. Additionally, portable mass spectrometry and 3D-printed devices have expanded the range of what can be tested accurately at the bedside, from pathogenic bacteria to environmental toxins [8-10]. These technological advancements, when coupled with automated data integration, effectively "bridge the gap" by bringing laboratory-grade precision to the point of care [1,7].

Discussion

The results of this systematic review underscore a fundamental tension in modern healthcare: the drive for diagnostic speed versus the necessity for laboratory-grade precision. The findings highlight that while Point-of-Care Testing (POCT) is an invaluable tool for acute clinical management, its success is entirely dependent on the robustness of the quality assurance framework led by nursing staff [1,12]. One of the most critical interpretations of the data is that "Labora-

tory Excellence at the Bedside" is not merely a technical goal but an organizational one [5]. The barriers identified—such as time constraints and fragmented training—suggest that the current model of POCT implementation often fails to account for the "human factor" in nursing practice [6,13]. A significant implication of these results is the need for a shift from "operator-dependent" testing to "system-dependent" testing. The integration of AI and machine learning represents a transformative opportunity in this regard [17]. By automating the QC process and providing intelligent decision support, these technologies can mitigate the risks associated with the varying skill levels of nursing staff [16]. This is particularly relevant in complex diagnostic areas, such as sepsis detection or multiorgan ultrasound, where the interpretation of data is as critical as the collection itself [12,15].

The evidence suggests that technology should be used to "guardrail" nursing practice, ensuring that the excellence of the laboratory is hard-wired into the bedside device [1,7]. Furthermore, the results highlight that the "gap" between nursing and laboratory services is largely a result of poor interdisciplinary governance [4]. The success of POCT in managing diseases like COVID-19 or Hepatitis B DNA demonstrates that when clear, collaborative clinical pathways are established, the technology becomes a powerful enabler of care [14,18]. However, this requires laboratory professionals to step out of the central lab and into a consultative role, and for nursing leadership to prioritize diagnostic quality as a core component of patient safety [4,5]. The implementation of frameworks like the Selwan Sorption-Safe framework shows that nursing-led initiatives can effectively bridge this gap when they are evidence-based and professionally supported [13]. Finally, the advancement of portable mass spectrometry and advanced biosensors suggests that the scope of POCT will only continue to expand [7,8]. This expansion brings with it the responsibility to ensure that decentralized testing does not lead to decentralized quality [1].

The clinical and policy implications are clear: healthcare institutions must invest in integrated digital infrastructures that allow for real-time monitoring of POCT performance across all units [1,5]. Only through a combination of technological innovation, interdisciplinary collaboration, and rigorous nursing leadership can laboratory excellence be truly realized at the bedside [4].

Conclusion and Recommendations

The integration of Point-of-Care Testing into the clinical workflow has fundamentally changed the nature of nursing practice and laboratory diagnostics. This review has demonstrated that while POCT offers unparalleled benefits in terms of speed and patient-centered care, these advantages are contingent upon a rigorous nursing-led quality assurance framework. The gap between bedside testing and laboratory excellence is not an inherent flaw of the technology but rather a result of organizational silos and inconsistent training. By fostering a culture of interdisciplinary collaboration, healthcare systems can ensure that the diagnostic accuracy of the central laboratory is maintained at the patient's side. The rise of artificial intelligence and advanced biosensors provides a promising pathway to automate quality control and reduce the burden on frontline staff, yet these tools must be supported by evidence-based clinical governance. Ultimately, the success of POCT lies in the synergy between technical precision and clinical expertise, ensuring that rapid results lead to safe and effective patient outcomes. To ensure the successful integration of laboratory excellence at the bedside, healthcare institutions must move beyond ad-hoc testing and establish a formal interdisciplinary POCT governance committee.

This committee should bring together nursing leaders, laboratory directors, and IT specialists to create a unified strategy for device selection, validation, and oversight. By breaking down the traditional silos between departments, organizations can ensure that nursing-led testing is supported by the technical expertise of the laboratory, creating a shared accountability framework that prioritizes diagnostic integrity alongside clinical speed. Furthermore, it is essential to bridge the educational gap by updating nursing curricula and hospital orientation programs to include the fundamental principles of laboratory science. Training should not merely focus on device operation but must emphasize the pre-analytical and analytical variables that can compromise results. This educational shift ensures that nursing staff are empowered not just as operators, but as informed clinicians capable of identifying potential errors and understanding the clinical implications of analytical variability. Technologically, the focus should shift toward the implementation of seamless digital connectivity and the adoption of intelligent monitoring systems. Ensuring that every POCT device is fully integrated with the Electronic Health Record (EHR) allows for real-time professional oversight and eliminates the risks associated with manual data entry.

Simultaneously, the integration of AI-driven decision support and machine learning can provide an automated "safety net," helping nurses interpret complex diagnostic markers and maintaining high standards of quality assurance without increasing the administrative burden on frontline staff. Finally, maintaining laboratory excellence at the bedside requires a commitment to continuous quality improvement through regular proficiency testing and clinical audits. Laboratory professionals should take an active, consultative role within clinical units, conducting "bedside audits" to ensure equipment is well-maintained and protocols are being followed. This ongoing presence fosters a culture of excellence and ensures that the rapid pace of the clinical environment never comes at the expense of the diagnostic accuracy required for safe patient care.

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