

Exploring the Impact of Laboratory Errors on Nursing Responsibilities and Patient Safety

Ummalkhayr Abdullah Alghirash¹, Huda Zaki Al Towailib², Duaa Ibrahim Alzawad³,
Awatif Ayish Algharrash⁴, Ahlam Mohammed Ali Alabdullah⁵, Safa Essa Al Badan⁶,
Ashwaq Mubarak Alhazzaa⁷, Layla Abdullah Asaeed⁸, Fatimah Hussain Aljanabi⁹,
Ramlah Abdulaziz A Alhaddad¹⁰, Rehab Khuder Alradi¹¹, Ali Mohammed Alobaidan¹²,
Alraddadi, Mohammed Muawidh¹³, Sulaiman Marzouq Alerwi¹⁴, Ghammari, Reem
Ahmed¹⁵

- 1- Nurse technician, Maternity and Children Hospital, Alahsa, Saudi Arabia
- 2- Nursing specialist, Dhahran Eye Specialist Hospital, Khobar, Saudi Arabia
- 3- Nursing technician, Dhahran Eye Specialist Hospital, Saudi Arabia
- 4- Nurse technician, Alfadhelia PHC, Saudi Arabia
- 5- Nurse technician, ALOMRAN GENERAL HOSPITAL, Saudi Arabia
- 6- Nurse technician, Alawamyah Primary Health Care, Alqatif Cluster, Saudi Arabia
- 7- Nurse technician, King Fahad Hospital, Hofuf, Saudi Arabia
- 8- Specialist nurse, Qatif Central Hospital (QCH), Saudi Arabia
- 9- Nursing specialist, Ministry of Health, Saudi Arabia
- 10- Nurse, Alkhobar PHC, Saudi Arabia
- 11- Lab technologist, Dammam regional laboratory, Saudi Arabia
- 12- Laboratory technician, ALOMRN GENERAL HOSPITAL, ALAHSa, Saudi Arabia
- 13- Lab technician, Madinah Health Cluster, Saudi Arabia
- 14- Lab technician, Madinah Health Cluster, Saudi Arabia
- 15- Nurse technician, Tabuk health cluster, Saudi Arabia

Abstract:

Laboratory errors can significantly impact nursing responsibilities and patient safety, underscoring the vital role that accurate lab results play in clinical decision-making. When nursing staff receive erroneous lab data—whether due to pre-analytical, analytical, or post-analytical mistakes—they may base critical interventions, medication administration, and care planning on inaccurate information. This reliance on faulty data can lead to inappropriate treatments, overlooked diagnoses, and ultimately adverse patient outcomes. Consequently, nurses must remain vigilant, implementing best practices in communication and verification of lab results to safeguard against the ripple effects of laboratory errors on patient care. Furthermore, the consequences of laboratory errors extend beyond immediate patient safety concerns, influencing the broader healthcare environment. Increased errors can lead to a loss of trust in the healthcare system, exacerbating patient anxiety and dissatisfaction. Additionally, the burden placed on nurses not only involves rectifying misunderstandings arising from lab errors but also requires them to engage in thorough patient education and support. By addressing these discrepancies, nurses can play a crucial part in enhancing patient safety and improving overall healthcare quality. Therefore, fostering a culture of transparency and collaboration between laboratory personnel and nursing staff is essential to minimize the potential for errors and reinforce a commitment to patient-centered care.

Keywords: Laboratory errors, nursing responsibilities, patient safety, pre-analytical, analytical, post-analytical, communication, verification, healthcare quality, trust, patient education, collaboration, patient-centered care.

Introduction:

In today's complex healthcare landscape, the provision of safe and effective patient care relies heavily on the harmonious interplay between various disciplines, notably nursing and laboratory services. Nurses serve as critical advocates for patients; they are often the first point of contact within healthcare settings and play an essential role in interpreting and acting upon laboratory results. However, the integrity of the data they rely upon hinges on the accuracy and reliability of laboratory processes. Laboratory errors—ranging from pre-analytical missteps to post-analytical misinterpretations—can profoundly affect patient outcomes, nursing responsibilities, and the overall safety of healthcare delivery [1].

Laboratory errors can be classified into several categories: pre-analytical, analytical, and post-analytical errors. Pre-analytical errors occur before the specimen reaches the laboratory and can stem from issues such as incorrect patient identification, improper specimen collection, or inadequate sample handling and storage. Analytical errors happen within the laboratory setting, often due to faulty equipment, reagent issues, or procedural deviations. Meanwhile, post-analytical errors reflect challenges in the interpretation, communication, or application of laboratory results. Each stage presents unique risks that can compromise patient safety, making it critical to explore their implications for nursing responsibilities [1].

The impact of laboratory errors on patient safety cannot be overstated. Research has consistently shown that diagnostic inaccuracies can lead to inappropriate treatment plans, delayed care, and increased morbidity and mortality rates. For nurses, the ramifications of these errors extend beyond the immediate consequences for patient health. Nurses are responsible for interpreting laboratory results, coordinating care plans, and communicating effectively with the healthcare team and patients. Therefore, when laboratory errors occur, nurses may face ethical dilemmas, increased workloads, and potential liability issues, all of which can negatively influence their capacity to provide safe, quality care [2].

Moreover, the role of nurses in safeguarding patient safety in the face of potential laboratory errors is multifaceted. They must not only rely on their clinical expertise to interpret test results accurately but also engage in vigilant practices to verify patient identity, ensure proper specimen collection

techniques, and communicate effectively with laboratory personnel. This heightened level of engagement is essential for mitigating risks associated with laboratory errors and ensuring that accurate diagnostic information informs patient care. Furthermore, the integration of advanced technologies, such as electronic health records and clinical decision support systems, can aid nurses in this double-edged challenge, providing both support and introducing potential new sources of error [3].

Despite the acknowledgment of laboratory errors as a significant threat to patient safety, the current literature reveals considerable gaps in understanding their full impact on nursing obligations. Numerous studies focus primarily on the technical aspects of laboratory error prevention, while neglecting the vital role of nurses as both primary caregivers and interpreters of laboratory data. As patient outcomes hinge on timely and accurate responses to diagnostic information, there is an urgent need for comprehensive research that addresses how laboratory errors influence the nursing profession and the strategies that can be implemented to bolster patient safety in these circumstances [3].

To address these critical gaps, this study aims to explore the impact of laboratory errors on nursing responsibilities and patient safety from a multifactorial perspective. By examining existing literature, surveying nursing professionals, and conducting case studies of incidents involving laboratory errors, this research seeks to provide actionable insights that can inform practice and policy. Ultimately, the goal is to foster enhanced communication between nursing and laboratory staff, cultivate a culture of safety and accountability, and promote improved patient outcomes through a better understanding of the interconnectedness of nursing and laboratory practices [4].

Understanding Types of Laboratory Errors: Causes and Consequences:

In the realm of clinical laboratories, precision and accuracy are paramount. Laboratory errors can have far-reaching consequences, affecting patient care, treatment outcomes, and overall trust in the healthcare system. Understanding the various types of laboratory errors, including their causes and consequences, is critical not only for laboratory personnel but also for clinicians and patients alike [5].

Classification of Laboratory Errors

Laboratory errors can be broadly categorized into three main phases: pre-analytical, analytical, and post-analytical errors. Each phase presents unique challenges and potential pitfalls.

1. **Pre-Analytical Errors:** This category includes any mistakes that occur before the actual testing of specimens. Pre-analytical errors are often the most prevalent, accounting for a significant percentage of laboratory errors. They can stem from:

- **Specimen Collection:** Incorrect patient identification, incomplete patient preparation, wrong specimen type collection, and improper labeling can all lead to errors. For instance, if a blood sample is collected from the wrong patient, it may lead to life-threatening consequences.
 - **Transportation and Handling:** Inadequate transportation conditions—such as temperature fluctuations or delays—can compromise specimen integrity. Blood samples, for example, may degrade if not kept at proper temperatures during transit.
 - **Clerical Errors:** Data entry mistakes, such as transcribing patient information or mixing up accession numbers, can lead to significant confusion and misdiagnosis [6].
2. **Analytical Errors:** These occur during the actual testing process. They may arise due to:
- **Instrument Malfunction:** Equipment failure or calibration errors can produce incorrect results. For instance, an improperly calibrated glucometer can lead to erroneous blood glucose readings, impacting diabetic patient management.
 - **Reagent Issues:** The use of expired, contaminated, or improperly stored reagents can affect the reliability of test results.
 - **Operator Error:** Inadequate training or fatigue can result in mistakes in following protocols or interpreting results. Human factors such as stress can also contribute to analytical errors [7].

3. **Post-Analytical Errors:** These errors occur after the testing phase and can include:

- **Result Reporting:** Mistakes in communicating results, whether through unintentional transcription errors or failures in using established reporting protocols, can lead to incorrect clinical decisions.

- **Interpretation Errors:** Clinicians may misinterpret lab results due to lack of context, clinical correlation, or insufficient knowledge, leading to inappropriate patient management [8].

Causes of Laboratory Errors

The causes of laboratory errors are multifaceted and can be classified into human, technical, and systemic factors [9].

- **Human Factors:** Many errors can be traced back to inadequate training, fatigue, distractions, and communication failures among staff. Human behavior is inherently variable, which means even experienced professionals can make mistakes under pressure or due to complacency.
- **Technical Factors:** These include equipment failure, reagent quality, and the complexity of test methods. Advanced diagnostic technologies, while providing crucial insights, introduce additional layers of potential error. High-throughput systems, for example, may generate data faster, but they also risk cascading errors in result reporting.
- **Systemic Factors:** These are organizational issues that affect workflow and processes. Inadequate protocols, poor laboratory design, and inefficient management can create environments prone to error. For instance, a poorly designed laboratory layout may lead to confusion during specimen handling and processing, increasing the likelihood of errors [9].

Consequences of Laboratory Errors

The ramifications of errors in laboratory settings can be severe, affecting various stakeholders in the healthcare continuum [10].

1. **Impact on Patient Care:** At the most fundamental level, laboratory errors can endanger patient safety. An inaccurate diagnosis can result in inappropriate or delayed treatment. For example, a false-negative result for a serious infectious disease could lead to a lack of timely intervention, allowing the infection to progress unchecked [10].
2. **Increased Healthcare Costs:** Errors can lead to additional testing, repeat procedures, or prolonged hospitalizations, ultimately inflating healthcare costs. Furthermore, misdiagnosis may prompt unnecessary treatments that place further financial burdens on patients and healthcare systems [10].

3. **Legal and Regulatory Implications:**

Laboratory errors can expose healthcare providers to legal risks, including malpractice claims. Regulatory bodies may also impose penalties or sanctions on laboratories that fail to maintain proper quality assurance standards [10].

4. **Erosion of Trust:** Repeated or high-profile laboratory errors can erode public trust in the healthcare system. Patients rely on the accuracy of laboratory results for informed clinical decision-making; failure to provide reliable data can undermine confidence in healthcare providers and institutions [11].

5. **Impact on Laboratory Staff:** Errors can lead to decreased morale among laboratory personnel, particularly if the environment feels punitive rather than supportive. A culture that fosters fear of blame may dissuade employees from reporting errors or near misses, stifling opportunities for improvement and learning [11].

The Role of Nurses in the Laboratory Result Verification Process:

In the complex landscape of healthcare, the role of nurses transcends traditional boundaries, often extending into realms such as diagnostic testing and laboratory result verification. As the frontline caregivers in various clinical settings, nurses serve not only as practitioners but also as vital intermediaries in ensuring the accuracy and effectiveness of laboratory results. Their involvement in the verification process is critical for patient safety, care continuity, and overall clinical decision-making [12].

The laboratory result verification process involves several key steps, which begin once a specimen is collected from a patient. It continues with the processing and analysis of the sample in the laboratory, followed by the generation of results. Before these results are communicated to healthcare providers, they must undergo verification to ensure their accuracy, reliability, and clinical relevance. This process involves critical assessments, including initial validation of the test methodologies, comparison of results against established reference ranges, and recognition of any abnormalities that necessitate further investigation or action [13].

Nurses play a pivotal role in this continuum by acting as the primary point of contact for laboratory results within clinical settings. Their responsibilities

include order placement, result retrieval, and notification of results to the relevant healthcare providers as well as to patients when appropriate. The complexity of laboratory tests and the potential for errors underscore the importance of having skilled professionals involved at every stage of this process [14].

The Responsibilities of Nurses in Laboratory Result Verification

1. **Specimen Collection and Preparation:** The verification process begins with the collection of samples, during which nurses are integral. They must adhere to strict protocols for sample collection, ensuring that proper techniques are followed to prevent contamination or degradation. Proper labeling and documentation are essential components of this stage, as any errors can lead to misinterpretation of results [15].

2. **Order Placement:** Once samples are collected, nurses play a critical role in placing laboratory orders. This involves understanding the clinical context in which the tests are being requested and confirming that the appropriate tests are selected based on patient symptoms and medical history. Any discrepancies at this stage can lead to unnecessary tests or missed diagnoses, emphasizing the importance of nurse involvement [16].

3. **Monitoring Results:** After laboratory tests are conducted, it is the responsibility of nurses to monitor the results as they are generated. This includes staying organized in tracking incoming results and ensuring that they are promptly reviewed by the appropriate healthcare provider. In many healthcare settings, nurses are also responsible for flagging results that fall outside normal ranges or where critical values are identified, thereby facilitating timely clinical response [16].

4. **Interpreting and Communicating Results:** Although the primary interpretation of complex laboratory tests is generally the domain of physicians, nurses often assist in communicating preliminary findings to patients or other healthcare staff. They must possess a foundational understanding of the tests performed and be able to convey this information in a manner that is comprehensible to patients, addressing any questions or concerns that may arise. This not only enhances patient

understanding but also fosters trust in the healthcare team [17].

- 5. Collaborative Decision-Making:** The laboratory result verification process is inherently collaborative, involving an interdisciplinary approach. Nurses must work closely with laboratory personnel, physicians, and other members of the healthcare team to ensure that all pertinent information is considered and that decisions regarding patient care are made collectively. This collaboration is vital for ensuring that any critical findings are addressed promptly and that appropriate follow-up actions are implemented [17].

Challenges Faced by Nurses in the Verification Process

Despite the crucial role nurses play in laboratory result verification, they face numerous challenges. High patient volumes, staffing shortages, and tight schedules can impede their ability to effectively monitor and communicate laboratory results. Additionally, the increasing complexity of laboratory testing technology necessitates ongoing education and training to ensure nurses remain competent in interpreting and utilizing laboratory findings [18].

Another significant challenge is the potential for information overload. With the proliferation of electronic health records (EHRs) and laboratory information systems, nurses are tasked with navigating vast quantities of data. This can lead to difficulty in identifying critical information amidst a plethora of non-essential findings, heightening the risk of overlooking important results that require immediate attention [18].

Moreover, interdisciplinary communication can sometimes falter, leading to misunderstandings or delays in patient care. Establishing clear channels of communication and protocols for result verification among healthcare team members is essential for mitigating these challenges and enhancing collaborative decision-making [19].

To mitigate the challenges faced by nurses in the laboratory result verification process, it is essential to prioritize education and standardization. Ongoing professional development opportunities should focus on enhancing nurses' knowledge of laboratory medicine, interpretation of results, and the significance of abnormal findings. Training sessions that include practical aspects, such as case studies and simulations, can be highly beneficial in building

nurses' confidence in utilizing laboratory data effectively [20].

Standardization of procedures within healthcare institutions also plays a crucial role in ensuring consistency and reliability in the verification process. Implementing standardized protocols for communication, documentation, and follow-up actions can facilitate a more streamlined workflow, ultimately benefitting patient outcomes [21].

Impact of Laboratory Errors on Clinical Decision-Making and Patient Outcomes:

Laboratory medicine plays a crucial role in contemporary healthcare decision-making, serving as a cornerstone for accurate diagnosis, treatment, and patient management. The information derived from laboratory tests significantly influences clinical decisions, directing therapeutic interventions, prognostic evaluations, and monitoring of disease progression. However, laboratory errors can jeopardize this process, leading to misguided clinical decisions and detrimental patient outcomes [21].

Types of Laboratory Errors

Laboratory errors can be categorized into several key phases: pre-analytical, analytical, and post-analytical. Each phase contributes uniquely to the potential for mistakes [22].

1. Pre-analytical Errors:

Pre-analytical errors occur before the actual analysis of specimens and account for a significant portion of laboratory mistakes—estimates suggest they may constitute over 70% of all lab errors. These errors arise from various factors, including improper specimen collection, incorrect labeling, inadequate sample transport conditions, and insufficient patient preparation. For example, an error in blood sample collection — whether it be a failure to appropriately fast the patient or mislabeling the specimen — can yield results that do not accurately reflect the patient's condition [22].

2. Analytical Errors:

Analytical errors are those that occur during the processing and analysis of the samples. These can arise from instrument malfunctions, reagent issues, or human error while conducting tests. While technology has advanced significantly, laboratory information systems can be complex and prone to faults, resulting in incorrect readings or misinterpretation of data. A notable example includes erroneous glucose levels resulting from calibration failures in glucometers, potentially

leading to inappropriate management of diabetes [22].

3. **Post-analytical Errors:**

Post-analytical errors involve the interpretation and communication of test results. These may include transcription errors, failure to notify the clinical team of critical values, or miscommunication among medical staff. A failure to promptly communicate abnormal results can delay treatment and critical interventions, ultimately jeopardizing patient safety [23].

Impact on Clinical Decision-Making

Laboratory errors directly influence clinical decision-making, which is increasingly reliant on precise, timely, and accurate laboratory data. When errors occur, the consequences can be far-reaching:

1. **Misdiagnosis and Delay in Treatment:**

One of the most severe consequences of laboratory errors is misdiagnosis. A false-negative result can result in the under-treatment of a critical condition, such as cancer or serious infections, while a false-positive result may lead to unnecessary and potentially harmful interventions. For instance, inaccurate thyroid function tests may lead to mismanagement of thyroid disorders, with serious implications for the patient's health. Furthermore, any delay in diagnosis or treatment attributable to laboratory errors can lead to disease progression and potentially irreversible health issues [24].

2. **Increased Healthcare Costs:**

Laboratory errors can significantly inflate healthcare costs. Consequences such as repeat testing, additional consultations, and extended hospital stays due to misdiagnosis all contribute to increased expenses for both healthcare providers and patients. For instance, if a laboratory error leads to unnecessary surgical procedures, not only are there direct costs associated with the surgery, but there are also indirect costs, such as rehabilitation and lost wages for the patient [24].

3. **Erosion of Trust in Healthcare Systems:**

When patients encounter laboratory errors, their trust in healthcare providers and systems can diminish. Confidence in diagnostic processes is paramount for patient compliance with treatment plans and adherence to follow-up appointments. Consequently, if patients perceive the lab results as unreliable, they may hesitate to seek medical attention when needed, posing a threat to their health [25].

4. **Legal and Ethical Implications:**

Laboratories and healthcare providers may face legal repercussions for errors that adversely affect patient outcomes. Malpractice claims can arise if it can be demonstrated that a laboratory error directly contributed to a negative clinical outcome. This raises ethical questions about accountability and the importance of transparent reporting and rectification of errors in healthcare settings [26].

Improving Laboratory Practices and Patient Safety

The impact of laboratory errors on clinical decision-making and patient outcomes highlights the need for robust systems to mitigate risks. Strategies to enhance laboratory practices include:

1. **Standardization and Protocol Compliance:**

Establishing standardized protocols for specimen collection, handling, and reporting can significantly reduce pre-analytical, analytical, and post-analytical errors. Training healthcare personnel involved in laboratory processes is essential and should be routinely updated to include best practices and technological advancements [27].

2. **Implementation of Quality Control Measures:**

Regular quality assurance programs can involve routine checks of laboratory equipment, validation of testing methods, and review of protocols. Continuous monitoring systems can detect anomalies in laboratory results that may indicate errors, thereby minimizing their impact [28].

3. **Enhanced Communication and Documentation Systems:**

Improving communication pathways between laboratories and clinical teams is vital. Leveraging technology, such as automated alerts for critical values and streamlined reporting systems, can ensure timely updates to healthcare providers regarding lab results [28].

4. **Patient Engagement:**

Involving patients in their healthcare processes can ensure they remain informed about their treatments and the importance of laboratory testing. Educating patients to understand their test results may foster a partnership approach and prompt them to seek clarification if needed [29].

Best Practices for Minimizing Laboratory Errors in Nursing Practice:

Laboratory errors can have serious implications for patient outcomes, potentially leading to incorrect diagnoses, inappropriate treatments, and ultimately, patient harm. In nursing practice, nurses play a critical role in the transference of laboratory data from the testing phase to patient care. Therefore, minimizing errors within laboratory processes is crucial for ensuring the safety and effectiveness of patient management [30].

Laboratory errors can be categorized into three main phases: pre-analytical, analytical, and post-analytical. The pre-analytical phase involves the collection, handling, and transportation of samples. The analytical phase refers to the actual testing of samples, while the post-analytical phase includes result interpretation and communication to healthcare providers. Studies suggest that a significant proportion of laboratory errors occur during the pre-analytical phase, often due to improper sample collection or mislabeling. Addressing errors in all phases is critical to improving patient safety and care outcomes [31].

Pre-Analytical Best Practices

1. **Standardized Protocols for Sample Collection:** Establishing and adhering to standardized protocols for specimen collection is essential. This includes using correct techniques for blood draws, urine collection, and other biological samples. Nurses should utilize evidence-based guidelines to ensure consistency and reliability in sample acquisition.

2. **Proper Patient Identification:** One of the most effective strategies to reduce laboratory errors is accurate patient identification. Nurses should implement a two-step verification process by confirming the patient's identity using at least two identifiers, such as name and date of birth, prior to specimen collection [32].

3. **Training and Competency Assessments:** Regular training sessions and competency assessments for nursing staff can help maintain high standards in sample collection and handling. Educational programs should not only cover technical procedures but also reinforce the importance of adhering to protocols to minimize errors [33].

4. **Effective Management of Specimen Transport:** Improper transport conditions can adversely affect laboratory results. Nurses must ensure that specimens are stored and transported under the appropriate conditions, such as

temperature controls, and are delivered to the laboratory promptly [34].

Analytical Best Practices

1. **Engagement with Laboratory Personnel:** Nurses should foster strong communication lines with laboratory personnel to ensure understanding of the tests being ordered and the implications of results. Collaborating closely with laboratory staff can help nurses appreciate any limitations or potential issues with specific tests [35].

2. **Utilization of Technology:** Automation and advanced laboratory information systems can help minimize errors during the analytical phase. Incorporation of barcode scanning technology for both specimens and result reporting can significantly reduce chances of misidentification and transcription errors.

3. **Quality Control Measures:** Understanding and promoting the importance of internal quality control measures in the laboratory is critical. Nurses should advocate for routine checks and balances to ensure that laboratory equipment is functioning appropriately and that procedures are consistently followed [35].

Post-Analytical Best Practices

1. **Timely and Accurate Result Communication:** Effective communication is vital for translating laboratory results into actionable treatment plans. Nurses should ensure that results are communicated promptly to the appropriate healthcare professionals and that any critical findings are conveyed without delay [36].

2. **Thorough Result Interpretation:** It is essential for nurses to possess a foundational understanding of the laboratory results to provide context for patient care. Training in the interpretation of common laboratory tests will allow nurses to make informed clinical decisions based on results, which will help in identifying any irregularities [36].

3. **Documentation and Feedback Mechanism:** Implementing a robust documentation system aids in tracking laboratory results, communications, and any errors that may occur. Creating feedback loops where nurses can report perceived errors or discrepancies encourages accountability and continuous improvement [37].

Continuous Education and Professional Development

To combat laboratory errors, an ongoing commitment to education and professional development is essential. Nursing education programs should incorporate training focused on the significance of laboratory accuracy, error identification, and resolution strategies. Continuing education units (CEUs) for nurses can emphasize laboratory best practices, further enhancing their knowledge base and competencies in relation to laboratory-related tasks [38].

Moreover, multidisciplinary teamwork that includes input from laboratory personnel, medical staff, and nurses fosters a culture of safety and mutual respect for each profession's expertise. Case studies and scenario-based learning can help nurses discuss common errors and devise solutions collaboratively [39].

Communication Strategies Between Nursing Staff and Laboratory Personnel:

Effective communication is a cornerstone of healthcare, a critical component that underpins patient safety, clinical efficiency, and team collaboration. Within this multifaceted system, the interaction between nursing staff and laboratory personnel is particularly crucial. Both groups play essential roles in patient care, with nurses serving as the primary point of contact for patients and laboratory personnel conducting vital tests that inform diagnoses and treatment plans. Therefore, a detailed understanding of the communication strategies that can enhance interactions between these two bodies is essential for improving overall healthcare outcomes [40].

In healthcare, miscommunication can lead to errors, delays, and adverse patient outcomes. The complexity of medical environments demands clear and effective communication channels among all parties involved in patient care. Research indicates that up to 70% of sentinel events, which are unexpected occurrences involving death or serious physical or psychological injury, are attributable to poor communication. This reality underscores the necessity for structured and strategic communication methods, particularly between nursing staff and laboratory personnel [41].

To foster effective communication, it is crucial to first understand the distinct responsibilities of nurses and laboratory personnel. Nurses are integrally involved in patient assessment, administration of medication, monitoring of vital signs, and providing emotional support. Their communication is often

dynamic and requires a quick understanding of patient needs and responses to interventions [42].

Laboratory personnel, on the other hand, perform diagnostic tests, analyze biological specimens, and contribute to the interpretation of test results. Their work is primarily focused on providing accurate and timely data, which nurses and other healthcare providers rely upon for informed decision-making. Recognizing these complementary roles can help in establishing mutual respect and appreciation, which are foundational to effective communication [43].

Effective Communication Strategies

- 1. Standardized Communication Protocols:** Implementing standardized protocols such as SBAR (Situation-Background-Assessment-Recommendation) can significantly enhance the clarity and efficiency of communication. By using SBAR, nurses can clearly convey relevant information to laboratory personnel regarding patient conditions and urgency, while laboratory staff can communicate test results and implications succinctly [44].
- 2. Regular Interdisciplinary Meetings:** Scheduling regular meetings between nursing and laboratory personnel allows for the exchange of information, fostering collaboration and relationship building. These meetings provide a platform for discussing common challenges, setting mutual goals, and reviewing protocols that affect both parties [45].
- 3. Utilization of Technology:** In today's digital age, electronic health records (EHRs) serve as powerful tools for communication. They provide a centralized platform where nurses and laboratory staff can share and access patient information, lab results, and related notes in real time. The integration of laboratory information systems with EHR enhances the workflow and minimizes the likelihood of errors [46].
- 4. Encourage Open Lines of Communication:** An environment that encourages open communication is pivotal. Nurses should feel comfortable reaching out to laboratory personnel with questions or concerns about test orders or results. Similarly, laboratory staff should feel able to flag any issues concerning samples or results directly to nursing staff [47].
- 5. Training and Education:** Cross-training can be beneficial in helping each group understand the other's roles and challenges. Workshops that bring together nursing and laboratory staff for joint

training sessions can foster empathy and improve communication. By understanding the workflows and pressures each group faces, members can better appreciate each other's needs and constraints [48].

6. **Non-verbal Communication:** Awareness of non-verbal signals is just as important as verbal communication. Body language, tone of voice, and facial expressions play a significant role in interactions. Training staff to be aware of their non-verbal cues can help in reducing misunderstandings [49].

7. **Feedback Mechanisms:** Establishing formal and informal channels for feedback can facilitate continuous improvement in communication strategies. After major incidents or over time, collecting feedback on communication practices allows for adjustments that can enhance future interactions [50].

8. **Crisis Communication Skills:** During high-stress situations, it is critical that both nursing staff and laboratory personnel employ effective crisis communication strategies. Training on how to communicate in emergencies can streamline processes, reduce anxiety, and ensure that pertinent information is conveyed promptly [50].

9. **Pathway for Escalation:** Clear pathways for escalation of concerns or issues should be established. If a nurse encounters a significant delay or error in lab results, knowing whom to contact—and having clear protocols on how to escalate the situation—can help resolve issues before they compromise patient safety [50].

Case Studies: Real-World Examples of Laboratory Errors Affecting Patient Safety:

Laboratory errors are a significant concern in the healthcare sector, as they can have profound implications for patient safety, treatment outcomes, and overall public health.

Laboratory errors can be categorized into three phases: pre-analytical, analytical, and post-analytical. Pre-analytical errors occur before testing and can relate to issues such as specimen collection, handling, and storage. Analytical errors happen during the testing process itself, often due to faulty equipment, improper laboratory techniques, or incorrect test interpretations. Finally, post-analytical errors relate to issues that occur after testing, including the reporting of results and subsequent clinical actions based on those results. Each of these phases presents opportunities for errors that can significantly impact patient safety [51].

One of the most notorious cases of laboratory error occurred in a hospital where erroneous potassium levels led to a critical medical crisis. A middle-aged man, admitted for chest pain, was subjected to a battery of tests, including a potassium level assessment. Due to a pre-analytical error involving the improper handling of the blood sample, the potassium level was reported as being alarmingly high. The healthcare team, acting on the erroneous result, administered emergency treatment for hyperkalemia, including intravenous calcium gluconate and insulin with glucose to stabilize the patient's heart [52].

However, as subsequent tests using fresh blood samples indicated normal potassium levels, it became clear that the initial test was erroneous. The unnecessary administration of high-risk treatments not only exposed the patient to potential complications—such as cardiac arrest from the inappropriate treatment of hyperkalemia—but also caused psychological stress and a significant delay in receiving appropriate care for his actual medical needs. This case illustrates the grave implications of pre-analytical errors and highlights the need for rigorous specimen handling protocols to ensure the integrity of laboratory results [52].

In another striking case, a laboratory experienced a significant failure in its analytical phase, resulting in a false-negative HIV test. An individual, unaware of their risky exposure, underwent routine testing and received confirmation that they were HIV negative. The laboratory, however, utilized outdated test kits that had been improperly maintained, leading to incorrect results. As time passed, the individual engaged in high-risk behaviors, unaware that they were actually HIV positive [53].

Months later, when the individual sought further medical attention due to health complications, more accurate tests were conducted, revealing the true HIV status. Consequently, the delayed diagnosis led to missed opportunities for timely intervention and treatment, ultimately leading to significant health deterioration. This case underlines the importance of using validated and updated testing methods, as well as the implications of relying on laboratory results without cross-verifying them with clinical assessments [54].

A critical instance of post-analytical error arose in a hospital where a technician mislabelled test results due to a breakdown in communication protocols. A patient diagnosed with an infection underwent routine blood cultures, which indicated the presence

of a resistant strain of bacteria. However, due to a clerical error, the results were reported to the treating physician incorrectly. Instead of the resistant strain, the physician received results indicating sensitivity to first-line antibiotics [54].

Consequently, the physician prescribed an ineffective treatment regimen, believing that the infection was manageable with standard antibiotics. Over time, the patient's condition worsened due to the inappropriate treatment. When the mistake was discovered through follow-up tests, the medical team had to scramble to institute a more aggressive treatment approach for a now-severe infection. This incident emphasizes that effective communication and diligent verification of laboratory results are paramount; small clerical errors can have devastating implications [55].

Analysis and Takeaways

These case studies starkly illustrate the myriad ways in which laboratory errors can affect patient safety and treatment outcomes. Notably, they highlight key areas for improvement within laboratory operations, including:

- 1. Standardization of Procedures:** Developing and rigidly implementing standard operating procedures (SOPs) for specimen collection, handling, and testing can mitigate pre-analytical errors.
- 2. Investment in Technology:** The adoption of modern technology and automated systems can reduce human error, particularly in specimen tracking and data entry.
- 3. Training and Continual Education:** Ongoing training for laboratory personnel on the latest testing techniques, equipment usage, and safety protocols is essential to minimize human errors.
- 4. Clear Communication:** Establishing clear lines of communication among laboratory staff, healthcare providers, and patients can prevent misunderstandings that lead to erroneous treatment decisions.
- 5. Quality Assurance Programs:** Implementing robust quality assurance and quality control programs allows for regular feedback and evaluation of laboratory processes, ensuring that errors are identified and corrected promptly [56].

Recommendations for Policy Improvements and Future Research Directions:

In the healthcare sector, nursing staff and laboratory workers embody critical roles in the provision of care and the diagnosis of diseases. Effectively functioning healthcare systems must recognize the interconnectivity of these roles and strive for cohesive policies that promote efficiency, safety, and optimal patient outcomes [57].

The Importance of Interdisciplinary Collaboration

One of the foundational recommendations for policy improvement is fostering a culture of interdisciplinary collaboration. Many healthcare organizations still operate under outdated models that place nurses and laboratory personnel in largely siloed roles. Policies fostering collaboration could encourage regular interdisciplinary meetings, joint training sessions, and shared clinical responsibilities, where nurses and laboratory personnel work closely on patient cases [58].

Recommendation: Develop and implement policies that mandate multidisciplinary team meetings involving nursing staff and laboratory workers. These meetings would not only encourage the exchange of valuable insights but also create a unified approach to patient care. For example, a case where a nursing team identifies a potential infection could immediately involve laboratory staff in expedited testing, leading to timely diagnosis and treatment [59].

Enhancing Communication

Effective communication is essential for optimal workflow and patient outcomes. However, misunderstandings or the absence of clear communication protocols can lead to errors, delays in treatment, or adverse patient outcomes. Policies should be designed to streamline communication between nursing staff and laboratory personnel [60].

Recommendation: Implement standardized communication tools, such as electronic health records (EHR) systems that include dedicated channels for laboratory results reporting and real-time updates. Policies could mandate immediate notification of critical lab results to nursing staff and require regular educational sessions on best practices for utilizing EHR tools. Enhanced communication can improve the workflow and reduce delays in patient care [61].

Training and Professional Development

Continued education and training are critical for both nursing staff and laboratory workers to keep

pace with advancements in their fields. A lack of competency in specific areas can adversely affect patient care and laboratory results [61].

Recommendation: Establish stronger policies focused on mandatory continuing education programs that address the evolving standards of care, technological advancements, and emerging pathogens. Collaborative training programs can also be developed, allowing nursing and laboratory staff to learn together. Research indicates that cross-trained personnel are often more competent and comfortable in interdisciplinary roles, reducing friction and improving teamwork [62].

Enhancing Workplace Conditions

Research consistently suggests that workplace conditions, including staffing ratios, resources, and morale, can significantly impact both job satisfaction and patient care quality. Nurses and laboratory staff often face high levels of stress, which can hinder their ability to perform optimally [62].

Recommendation: Policies should prioritize mental health support, adequate staffing ratios, and resource availability. Creating channels for feedback regarding workplace conditions can help management understand the challenges faced by nursing and laboratory staff. Furthermore, fostering a culture of recognition and appreciation can directly correlate with job performance and overall job satisfaction [63].

Policy Implementation and Evaluation

For any policy to be effective, it must be regularly assessed and evaluated. The implementation should include measurable targets and outcomes to gauge effectiveness [63].

Recommendation: Establish robust mechanisms for evaluating the impact of new policies on patient outcomes, staff satisfaction, and operational efficiency. This might include regular surveys, monitoring patient satisfaction scores, and collecting data on error rates and laboratory turnaround times. Addressing feedback proactively will ensure that policies remain adaptive and responsive to the needs of both staff and patients [64].

Future Research Directions

While existing literature provides a foundation for understanding the interplay of nursing and laboratory roles, substantial gaps remain. Future

research should seek to explore the following areas further:

1. **Impact of Interdisciplinary Training:** Investigate how comprehensive interdisciplinary training programs affect collaboration between nursing and laboratory staff. Understanding the tangible benefits of shared training and knowledge can further justify the need for policy changes in healthcare settings [64].
2. **Technology Integration:** Examine the effects of telehealth and advanced laboratory technologies on nursing and laboratory collaboration. Research can identify optimal ways to implement and use technology to streamline processes and improve patient care [65].
3. **Staff Well-being and Patient Outcomes:** There is a growing recognition of the link between staff mental health and patient outcomes. Future research could investigate clinical and administrative practices that promote nurse and laboratory worker well-being, particularly in high-stress environments [66].
4. **Diversity and Inclusivity:** Explore how diverse and inclusive work environments impact collaboration and communication between nursing and laboratory staff. Research can focus on the role of cultural competence in improving patient care [67].

Conclusion:

In conclusion, the exploration of laboratory errors highlights their profound impact on nursing responsibilities and patient safety. The reliance on accurate laboratory results is integral to effective clinical decision-making, and any discrepancies can lead to significant adverse outcomes for patients. Nurses, as frontline healthcare providers, are uniquely positioned to identify and mitigate the risks associated with laboratory errors through diligence in verifying results, effective communication with laboratory staff, and implementing best practices in patient care.

Moreover, fostering a culture of collaboration and transparency within healthcare environments is essential for reducing the likelihood of errors and enhancing overall patient safety. Continuous education and training for nursing staff on the complexities of laboratory processes, alongside systemic improvements in laboratory practices, can help bridge the gap between laboratory work and

nursing responsibilities. By placing patient safety at the forefront and prioritizing strategies to address and rectify laboratory errors, the healthcare community can better ensure optimal patient outcomes and maintain trust in the healthcare system. Future research should focus on developing targeted interventions and policies that further reduce laboratory errors and enhance the synergy between nursing and laboratory disciplines.

References:

1. Plebani M. The detection and prevention of errors in laboratory medicine. *Ann Clin Biochem.* 2010;47:101–110.
2. Carraro P, Plebani M. Errors in a stat laboratory: types and frequencies 10 years later. *Clin Chem.* 2007;53:1338–1342.
3. Noble MA, Restelli V, Taylor A, et al. Laboratory error reporting rates can change significantly with year-over-year examination. *Diagnosis (Berl).* 2018;5:15–19.
4. Aston ML, Shojania KG, Hamill TR, et al. Classifying laboratory incident reports to identify problems that jeopardize patient safety. *Am J Clin Pathol.* 2003;120:18–26.
5. Langelaan M, Broekens MA, Bruijne MC, et al. Monitor zorggerelateerde schade 2015/2016: dossieronderzoek bij overleden patiënten in Nederlandse ziekenhuizen. NIVEL. 2017.
6. Graber M. Diagnostic errors in medicine: a case of neglect. *Jt Comm J Qual Patient Saf.* 2005;31:106–113.
7. Zwaan L, El-Kareh R, Meyer AND, et al. Advancing diagnostic safety research: results of a systematic research priority setting exercise. *J Gen Intern Med.* 2021;36:2943–2951.
8. Hawkins R. Managing the pre- and post-analytical phases of the total testing process. *Ann Lab Med.* 2012;32:5–16.
9. O’Kane M. The reporting, classification and grading of quality failures in the medical laboratory. *Clin Chim Acta.* 2009;404:28–31.
10. Schiff GD, Hasan O, Kim S, et al. Diagnostic error in medicine: analysis of 583 physician-reported errors. *Arch Intern Med.* 2009;169:1881–1887.
11. Balogh EP, Miller BT, Ball JR. Committee on Diagnostic Error in Health Care; Board on Health Care Services; Institute of Medicine; Improving Diagnosis in Health Care. Washington, DC: National Academies Press (US); 2015.
12. Snyderman LK, Harubin B, Kumar S. Voluntary electronic reporting of laboratory errors: an analysis of 37,532 laboratory event reports from 30 health care organizations. *Am J Med Qual.* 2012;27:147–153.
13. Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. *Arch Intern Med.* 2005;165:1493–1499.
14. Plebani M, Laposata M, Lundberg GD. The brain-to-brain loop concept for laboratory testing 40 years after its introduction. *Am J Clin Pathol.* 2011;136:829–833.
15. Restelli V, Taylor A, Cochrane D, et al. Medical laboratory associated errors: the 33-month experience of an on-line volunteer Canadian province wide error reporting system. *Diagnosi.* 2017;4:79–86.
16. El-Kareh R, Hasan O, Schiff GD. Use of health information technology to reduce diagnostic errors. *BMJ Qual Saf.* 2013;22:ii40–ii51.
17. Gandhi TK, Kachalia A, Thomas EJ, et al. Missed and delayed diagnoses in the ambulatory setting: a study of closed malpractice claims. *Ann Intern Med.* 2006;145:488–496.
18. Plebani M. Exploring the iceberg of errors in laboratory medicine. *Clin Chim Acta.* 2009;404:16–23.
19. Inspectie Gezondheidszorg en Jeugd, Ministerie van Volksgezondheid, Welzijn en Sport. In openheid leren van meldingen 2016–2017.
20. van Vuuren W, Shea CE, van der Schaaf TW, et al. The development of an incident analysis tool for the medical field. EUT - BDK report. Department of Industrial Engineering and Management Science, Technical University Eindhoven. 1997.85.
21. Carraro P, Plebani M. Errors in a stat laboratory: types and frequencies 10 years later. *Clin Chem* 2007;53:1338-1342.
22. Steindel SJ, Howanitz PJ, Renner SW. Reasons for proficiency testing failures in clinical chemistry and blood gas analysis: a College of American Pathologists Q-Probes study in 665 laboratories. *Arch Pathol Lab Med* 1996;120:1094-1101.
23. Plebani M. The detection and prevention of errors in laboratory medicine. *Ann Clin Biochem* 2010;47:101-110.
24. Wahls TL, Cram PM. The frequency of missed test results and associated treatment delays in a highly computerized health system. *BMC Fam Pract* 2007;8:32-42.
25. Kachalia A, Gandhi TK, Pupolo AL, Yoon C, Thomas EJ, Griffey R, et al. Missed and

- delayed diagnoses in the emergency department: a study of closed malpractice claims from 4 liability insurers. *Ann Emerg Med* 2007;49:196-205.
26. Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. *Arch Intern Med*. 2005;165:1493-1499.
27. Plebani M, Carraro P. Mistakes in a stat laboratory: types and frequency. *Clin Chem* 1997;43: 1348-1351.
28. Hickner J, Graham DG, Elder NC, Brandt E, Emsermann CB, Dovey S, et al. Testing process errors and their harms and consequences reported from family medicine practices: a study of the American Academy of Family Physicians National Research Network. *Qual Saf Health Care* 2008;17:194-200.
29. O’Kane M. The reporting, classification and grading of quality failures in the medical laboratory. *Clin Chim Acta* 2009; 404:28-31.
30. Dalai BI, Bridgen ML. Factitious biochemical measurements resulting from hematologic conditions. *Am J Clin Pathol* 2009;131:195–204.
31. Gandhi TK, Kachalia A, Thomas EJ, Puopolo AL, Yoon C, Brennan TA, et al. Missed and delayed diagnoses in the ambulatory setting: a study of closed malpractice claims. *Ann Intern Med* 2006;145:488-496.
32. Plebani M. The CCLM contribution to improvements in quality and patient safety. *Clin Chem Lab Med* 2013;51:39-46.
33. Howanitz PJ. Errors in laboratory medicine: practical lessons to improve patient safety. *Arch Pathol Lab Med* 2005;129:1252-1261.
34. Witte VanNess SA, Angstadt DS, Pennell BJ. Errors, mistakes, blunders, outliers, or unacceptable results: how many? *Clin Chem* 1997;43:1352-1356.
35. Plebani M. Harmonization in laboratory medicine: the complete picture. *Clin Chem Lab Med* 2013;5:7411-7451.
36. Carraro P, Zago T, Plebani M. Exploring the initial steps of the testing process: frequency and nature of pre-analytic errors. *Clin Chem* 2012;58:638-642.
37. ISO/TS 22367:2008. Medical laboratories - reduction of error through risk management and continual improvement. Geneva, Switzerland: International Organization for Standardization, 2008.
38. Institute of Medicine (US) Committee on Quality of Health Care in America Kohn LT, Corrigan JM, Donaldson MS, editors. *To Err is Human: Building a Safer Health System*. Washington (DC): National Academies Press (US); 2000.
39. Plebani M. Exploring the iceberg of errors in laboratory medicine. *Clin Chim Acta* 2009;404: 16-23.
40. Belk WP, Sunderman FW. A survey of the accuracy of chemical analyses in clinical laboratories. *Am J Clin Pathol* 1947;17:853-861.
41. Yee D, Osuka H, Weiss J, Kriengkauykiat J, Kolwaite A, Johnson J et al. Identifying the priority infection prevention and control gaps contributing to neonatal healthcare-associated infections in low-and middle-income countries: results from a modified Delphi process. *J Glob Health Rep*. 2021;5.
42. Walton M, Woodward H, Van Staaldunin S, Lemer C, Greaves F, Noble D, et al. The WHO patient safety curriculum guide for medical schools. *Qual Saf Health Care*. 2010;19(6):542–6.
43. Ahmed FA, Asif F, Mubashir A, Aboumatar HJ, Hameed M, Haider A, et al. Incorporating Patient Safety and Quality into the Medical School Curriculum: an Assessment of Student gains. *J Patient Saf*. 2022;18(6):637–44.
44. Global Patient Safety Action Plan 2021–2030 towards eliminating avoidable harm in Health Care. Geneva: World Health Organization; 2021.
45. Nabilou B, Feizi A, Seyedin H. Patient safety in Medical Education: students’ perceptions, knowledge and attitudes. *PLoS ONE*. 2015;10(8):e0135610.
46. Svitlica BB, Šajnović M, Simin D, Ivetić J, Milutinović D. Patient safety: knowledge and attitudes of medical and nursing students: cross-sectional study. *Nurse Educ Pract*. 2021;53:103089.
47. Ortega J, Cometto MC, Zárate Grajales RA, Malvárez S, Cassiani S, Falconi C, et al. Distance learning and patient safety: Report and evaluation of an online patient safety course. *Rev Panam Salud Publica*. 2020;44:e33.
48. Ahmed FA, Choudhary RA, Khan H, Ayub F, Hassan SSU, Munir T, et al. Incorporating Patient Safety and Quality Course into the nursing curriculum: an Assessment of Student gains. *J Patient Saf*. 2023;19(6):408–14.
49. Levett-Jones T, Andersen P, Bogossian F, Cooper S, Guinea S, Hopmans R, et al. A cross-sectional survey of nursing students’ patient safety knowledge. *Nurse Educ Today*. 2020;88:104372.
50. Aveling EL, Kayonga Y, Nega A, Dixon-Woods M. Why is patient safety so hard in low-income countries? A qualitative study of healthcare workers’ views in two African hospitals. *Global Health*. 2015;11:6.

51. Elmontsri M, Banarsee R, Majeed A. Improving patient safety in developing countries - moving towards an integrated approach. *JRSM Open*. 2018;9(11):2054270418786112.
52. Aboumatar HJ, Thompson D, Wu A, Dawson P, Colbert J, Marsteller J, et al. Development and evaluation of a 3-day patient safety curriculum to advance knowledge, self-efficacy and system thinking among medical students. *BMJ Qual Saf*. 2012;21(5):416–22.
53. Commission PM. Pakistan Medical Commission Curriculum.
54. Institute of Medicine Committee on Quality of Health Care in A. In: Kohn LT, Corrigan JM, Donaldson MS, editors. *To Err is Human: Building a Safer Health System*. Washington (DC): National Academies Press (US); 2000.
55. Madigosky WS, Headrick LA, Nelson K, Cox KR, Anderson T. Changing and sustaining medical students' knowledge, skills, and attitudes about patient safety and medical fallibility. *Acad Med*. 2006;81(1):94–101.
56. Institute of Medicine Committee on Quality of Health Care in A. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington (DC): National Academies Press (US); 2001.
57. Bakhshi SK, Afzal N, Merchant AAH, Abdul Rahim K, Shaikh NQ, Noorali AA et al. Undergraduate Medical Education Curriculum reforms in Pakistan: a mixed methods study of Academic Leadership perspectives. *Acad Med*. 2024.
58. Oliveira JLC, Silva SVD, Santos PRD, Matsuda LM, Tonini NS, Nicola AL. Patient safety: knowledge between multiprofessional residents. *Einstein (Sao Paulo)* 2017;15(1):50–7.
59. Alsabri M, Boudi Z, Lauque D, Dias RD, Whelan JS, Östlundh L, et al. Impact of Teamwork and Communication Training interventions on Safety Culture and Patient Safety in Emergency departments: a systematic review. *J Patient Saf*. 2022;18(1):e351–61.
60. University AK. Aga Khan University MBBS Curriculum.
61. Brownlie K, Schneider C, Culliford R, Fox C, Boukouvalas A, Willan C. (2014). Medication reconciliation by a pharmacy technician in a mental health assessment unit. *Int J Clin Pharm*., 36(2):303–9.
62. Ali H., Ibrahim S. Z., Al Mudaf B., Al Fadalh T., Jamal D., & El-Jardali F. (2018). Baseline assessment of patient safety culture in public hospitals in Kuwait. *BMC Health Services Research*, 18, 158.
63. Fahimi F, Sistanizad M, Abrishami R, Baniasadi S. (2010). An observational study of errors related to the preparation and administration of medications given by infusion devices in a teaching hospital. *Iran J Pharm Res*., 6:295–299.
64. Schneider P (2012). *Medication Errors*. Edited by Parthasarathi G, NyfortHansen K, Nahata MC. *A Text Book of Clinical Pharmacy Practice, Essential Concepts and Skills*, 424–441.
65. Kohn LT, Corrigan JM, Donaldson MS. (1999). *To Err Is Human: Building a Safer Health System*. Institute of Medicine, Committee on Quality of Health Care in America. Washington, National Academy Press.
66. Reid-Searl K, Moxham L, Walker S, Happell B. (2008). Shifting supervision: implications for the safe administration of medication by nursing students. *J Clin Nurs*., 17(20): 2750–2757.
67. Grober E. D., & Bohnen J. M. A. (2005). Defining medical error. *Canadian Journal of Surgery*, 48(1), 39–44.