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A Comprehensive Review of Errors in Medical Laboratories and Strategies for Improvement

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ABSTRACT

Medical laboratories play a crucial role in healthcare by providing accurate and reliable test results that guide clinical decision-making. However, errors in the

laboratory testing process can lead to incorrect diagnoses, inappropriate treatments, and adverse patient outcomes. This comprehensive review examines the types, causes, and frequencies of errors in medical laboratories, as well as strategies for improvement. Errors can occur in the pre-analytical, analytical, and post-analytical phases of laboratory testing. Pre-analytical errors, which occur before the sample is analyzed, are the most common and can arise from issues such as improper patient preparation, incorrect specimen collection and handling, and inadequate sample transportation. Analytical errors, which occur during the testing process, are less frequent but can result from instrument malfunctions, calibration errors, and interfering substances. Post-analytical errors, which occur after the test is completed, can include incorrect result reporting, delayed communication of critical values, and misinterpretation of results. The causes of laboratory errors are multifactorial and can include human factors, such as inadequate training and poor communication, as well as technical factors, such as equipment failures and software glitches. To reduce errors and improve patient safety, laboratories must implement a comprehensive quality management system that includes standardized procedures, ongoing staff education and competency assessment, and continuous monitoring and improvement of processes. Strategies such as automation, barcoding, and the use of quality indicators can help identify and prevent errors. Additionally, collaboration between laboratory professionals, clinicians, and other healthcare providers is essential for ensuring the appropriate utilization of laboratory services and the timely communication of results. By understanding the types and causes of laboratory errors and implementing effective strategies for improvement, medical laboratories can enhance the quality and safety of patient care.

Keyword: medical laboratories. Laboratories Technician, Errors Medical laboratories.

Introduction

The Institute of Medicine (IOM) report, To Err Is Human: Building a Safer Health System (Institute of Medicine (US) Committee on Quality of Health Care in America, 2000), sparked significant debate and concern regarding patient injuries in healthcare. Patient safety, hitherto underappreciated in healthcare, has recently gained attention from journalists, leaders, and concerned individuals (Leape & Berwick, 2005). The IOM study has far-reaching ramifications across many disciplines, including pathology and laboratory medicine (Kalra, 2004). Laboratory test results have a significant role in clinical decision-making, accounting for 60-70% of key decisions such as admission, release, and medication (Forsman, 1996). Quality laboratory testing and reporting are crucial given their significant impact. Laboratory reporting plays a significant role in clinical decision-making and patient treatment, highlighting the need for higher quality standards (Plebani, 2002). Laboratory medicine activities are more accurate and controllable compared to emergency department procedures or treatments.

Laboratory medicine has a distinct edge as it pioneered statistical quality control (QC) efforts and is ahead of other clinical specialties in implementing quality improvement programs. The true number of errors in laboratory testing is unknown due to a lack of a systematic approach for determining frequency and eliminating

sources of error. Total testing is a difficult procedure with multiple steps that might lead to errors.

Modern diagnostics rely primarily on accurate laboratory test findings; hence it is critical to guarantee lab results are reliable and accurate (Chawla et al., 2010). A medical lab is critical in providing fast and accurate results of laboratory tests required for patient care. Laboratory tests are often available, even in small, limited-service facilities (Ph. D. McKenzie & Ph. D. Williams, 2010). Quality assurance in a laboratory is required to ensure that laboratory users receive accurate test results with high precision (HarsimranKaur et al., 2016). Quality assurance in the laboratory is to produce standardized, trustworthy test results (Karad, et al., 2017). To fulfil the goal of providing safe health care to patients, quality in medical diagnostics is critical (Alavi et al., 2020). A laboratory's total testing procedure (TTP) includes all steps, from test requisition to result receipt (Cornes et al., 2016). In over 70% of instances, clinical decisions are based on laboratory results, hence accuracy and dependability are critical. Clinical decisions such as admission, medication, and discharge are based on laboratory test findings, and the quality of test results should be prioritized because they play such an important role (Arul et al., 2018). Clinical laboratory errors can result in higher healthcare expenses and lower patient satisfaction (Raghavan A.T.M et al., 2020).

Laboratory errors are mistakes committed throughout the testing procedure. Such errors could be the result of misunderstanding among laboratory personnel, actions taken by others in the process, or a poorly planned procedure (Parco et al., 2014). Laboratory errors have a significant impact and may cause a delay in diagnosis or treatment if detected prior to the release of results, resulting in patient inconvenience or anxiety, and in some cases, the opportunity for diagnosis or screening may be missed if the specimen cannot be retested. Furthermore, errors that go undetected before findings are released will present undesirable errors and may result in the erroneous diagnosis or missing diagnosis, unnecessary retesting or therapy, and may jeopardize the patient's safety (De la Salle, 2019).

Laboratory sample processing errors are classified into three types: preanalytical, analytical, and postanalytical errors (Chawla et al., 2010). Statland and Winkel created the phrase "preanalytical phase" in 1977 (Sonmez et al., 2020). Automation has considerably decreased mistakes in the analytical and postanalytical stages, but the preanalytical stage still has a long way to go because it is heavily reliant on manual labour (Mehndiratta et al., 2021). Although laboratory operations are highly automated, there are several variables that might alter laboratory results, the majority of which are caused by human interaction and thus preventable (Chandra et al., 2020; Shukla, 2016; Sonmez et al., 2020; Upreti et al., 2013).

For accurate results reporting, all three parts of the total test procedure must be error-free. A considerable proportion of preanalytical mistakes throughout laboratory processes have been proven to raise patient safety concerns (West et al., 2017). Preanalytical activity ranges from clinical requests for laboratory tests to sample preparation for analysis. According to reports, only 7-13% of errors occur in the analytical phase of the testing procedure, with the majority occurring in the preanalytical phase (46-68%) and remaining in the postanalytical phase (18-47%)

(Chandra et al., 2020; Cornes et al., 2016; Raghavan A.T.M et al., 2020). Although blood sample guidelines and standard techniques exist, they are not widely followed (Alavi et al., 2020). A study from Italy found that 62% of laboratory errors occurred during the preanalytical phase of the TTP before the specimen arrived in the laboratory (De la Salle, 2019). In a hematology laboratory, blood sample collection must be done safely and correctly, as faulty and dangerous techniques might lead to errors during analysis.

Although many nations' requirements have been modified to address the issue of inadequate training, there is a gap between the needed and present levels of knowledge and abilities for clinical laboratory professionals (Zima, 2010). Furthermore, certain medical laboratories have been able to deploy newer, more effective error-reduction technology. However, some, particularly those in community hospitals, have been unable to adopt them. The issues have significantly contributed to the numerous examples of errors in clinical laboratories (Zima, 2010). The result of such blunders is that patients receive poor-quality care.

Types of medical laboratories errors

Pre-analytical error

While the overall testing process is often classified into three major phases (pre-, intra-, and post-analytical), an examination of the beginning and end of the loop reveals that pre- and post-analytical steps are currently more error-prone than intra-analytical processes (Stroobants et al., 2003). In the pre-analytical phase, the presence of a pre-pre-analytical phase (i.e., processes undertaken outside of the clinical laboratory or under the direct control of laboratory workers) must be acknowledged. This step begins with test requests, patient and specimen identification, blood drawing, sample collection and handling, and concludes with specimen transportation to the laboratory.

Several research' findings point to the importance of the pre-pre-analytical phase. Misuse of laboratory services through inappropriate laboratory test requests is being investigated globally due to its impact on total expenses and the associated increased risk of medical errors and damage. The estimates of unnecessary laboratory tests vary greatly, ranging from 11% to 70% for general biochemistry and hematological tests, 5% to 95% for urine screens and microbiology, and 17.4% to 55% for cardiac enzymes and thyroid tests. Numerous studies have been performed to identify ways to decrease the overuse and misuse of laboratory tests. Combined efforts in this approach are more effective than individual initiatives. Furthermore, the implementation and dissemination of evidence-based laboratory guidelines should be accompanied by ongoing monitoring and clinical advice from laboratory specialists (Solomon et al., 1998). As a result, everyone agrees that providing consultation as part of a laboratory service is critical for improving appropriateness.

Accurate patient identification is one of the first stages in assuring accurate laboratory results; misidentification of patients and specimens can have catastrophic

repercussions. In 1995, a Q-Probes study discovered a 7.4% average wristband mistake rate and indicated that the error rate was connected to hospital size, with smaller hospitals having a larger error rate (Renner et al., 1993). A later Q-Tracks inter-laboratory quality improvement program, conducted between 1999 and 2000, revealed an initial error rate of 7.4%, which was reduced to 3.05% after constant monitoring and instructional measures (Howanitz et al., 2002). In the College of American Pathologists Q-Probe study (Valenstein & Meier, 1999, p. 66) conducted in 660 institutions, 5514 out of 114,934 outpatient requisitions (4.8%) were associated with at least one type of order entry error, such as discrepancies between tests ordered and transcribed in the laboratory computer, one or more discrepancies in the identity of patients or physicians, and incorrect test priority. In an Australian survey on transcribing and analytical errors, the transcription error rate reached 39%, with the most common types of errors being misidentification of the ordered tests, the requesting doctors, and/or the patient (Khoury et al., 1996). Studies have provided additional evidence that the evaluation of specimen adequacy is an important element in test result accuracy and usefulness (Jones et al., 1997).

Samples that are missing, coagulated, hemolyzed, inadequate, or incorrect due to improper specimen collecting and handling techniques may account for a significant portion of pre-analytical errors. Errors caused by the use of improper containers or procedures (for example, from the infusion route or with excessive aspiration force) highlight the necessity of inter-departmental collaboration in enhancing specimen collection and handling quality (Plebani & Bonini, 2002). In fact, some data show a considerable difference in the frequency of these errors across outpatients and inpatients (Plebani & Bonini, 2002).

This distinction should be attributed, in part, to the greater complexity of tests done and multiple blood draws for inpatients, as well as the more accurate control provided by laboratory professionals who perform sample drawings for outpatients. On the other hand, blood draws performed by ward personnel, who have a larger turnover and fewer specific expertise, may result in an increase in the number of errors. Overall, insufficient quantity and quality of specimens account for more than 60% of pre-analytical errors, while other causes, such as incorrect specimen identification, lack of proper signature, empty tube, lack or incorrect compilation of the accompanying form, sample not in ice, tube broken in the centrifuge, urine not acidified or without volume indication, have a lower incidence.

Less obvious pre-analytical mistakes come from fluctuations in plasma volume and metabolites caused by physical exercise (Lippi et al., 2002, 2004), tourniquet insertion (Lippi et al., 2005), and other patient-related physical factors (diet, stress, position) (Romero et al., 2005; Young, 2003).

Specimen preparation, which encompasses all the actions required to make a sample ready for analysis, includes log-in, centrifugation, aliquoting, pipetting, dilution, and batch sorting specimens for input into automated analyzers. The specimen preparation stage has received significant academic and commercial interest in recent years since it accounts for approximately 19% of the total cost of evaluating a single specimen and is also time-consuming (37% of the time spent getting a result).

Furthermore, the manual handling of potentially infectious samples poses a well-known risk to laboratory personnel (Plebani, 2006).

Indirect evidence of the risk of errors in this step can be found in publications dealing with the implications of automated preanalytical robotic workstations. Holman et al. found that the use of a pre-analytical workstation significantly reduced the amount of sorting, routing, pour-off, and labelling errors. Sorting and routing errors fell from 7950 to 477 per month, labelling errors from 6668 to 33 per month, and biohazard exposure occurrences from 2658 to 6 per month (Holman et al., 2002).

Analytical errors

In recent decades, standardization, automation, and technical developments have considerably improved the analytical reliability of laboratory results and reduced error rates (Stankovic, 2004). The high level of accuracy in blood product testing for infectious agents is one indication of success in reducing errors in the analytical phase. Because of nucleic acid testing, the contamination rate has decreased from 1 per 100 units to 1 infected unit in 1,800,000 units (Busch et al., 2003).

However, this is not the case in all areas of laboratory medicine: "quality design in a laboratory must begin with analytical quality because it is the essential quality characteristic of any laboratory test; unless analytical quality can be achieved, none of the other characteristics matter" (Westgard & Westgard, 2017). Furthermore, certain data demonstrate the importance of analytical errors in certain fields of laboratory medicine. In example, a body of evidence reveals the incidence and harmful consequences of analytical interferences in immunometric experiments (Bjerner et al., 2002; Kricka, 2000). Marks emphasized that analytical interference could occur with most current immunoassays, that errors related to these interferences can be difficult to identify, and that they can produce serious errors (Marks, 2002) and, as stated by other authors, "interference in immunossays is insidious and could adversely affect patient care" (Ismail & Barth, 2001). Analytical interferences can occur when individuals have unknown aberrant binding proteins, such as heterophilic antibodies, anti-animal antibodies, and anti-idiotypic antibodies. Interferences with reactions might cause incorrectly elevated or reduced readings, depending on their location (Kazmierczak & Catrou, 2000).

The level of interference may vary, but in a considerable proportion of cases (up to 82%) it was deemed large enough to have a potentially negative impact on patient cost and/or clinical care. Ismail and colleagues emphasized that interference has the greatest impact on clinical decisions for immunoassays with unambiguous "cutoff" limitations, such as tumor markers and cardiac troponin. Given the current limits of immunoassays, the level of interference, direction of bias, analyte concentration, and interferent concentration all need to be known before making appropriate clinical judgments.

More recent data emphasize the necessity of analytical precision. The National Institute of Standards and Technology (NIST) research on "The influence of

calibration error in medical decision making" reveals that calibration error, leading to analytical bias, is a crucial parameter determining the number of patients passing decision thresholds in practice recommendations. Because the signs and symptoms of hypercalcemia are nonspecific, a hypercalcemic laboratory finding can be validated by follow-up procedures such as intact parathyroid hormone assay, chest Xrays, 24-hour calcium measurement, ionized calcium measurement, and thyroid imaging (Sonntag & Loh, 2023). Based on their examination of approximately 89,000 patients who received serum calcium tests at the Mayo Clinic between 1998 and 1999, the authors determined that an analytical bias of 0.1 mg/dL might cost between $8 and $31 per patient. For an analytical bias of 0.5 mg/dL, the potential healthcare cost increase ranged between $34 and $89 per patient. With about 3.55 million US patients receiving screening serum calcium tests influenced by systematic bias, the potential economic costs range from $60 million to $199 million per year for analytic bias of 0.1 and 0.5 mg/dL, respectively. Furthermore, it is important to address the psychological and emotional effects on patients. The impact of analytical bias on medical and economic outcomes are well documented (Klee et al., 1999).

Post-analytical errors

Post-analytical quality, which is the final check on the consistency of pre- and intra-analytical quality, might be called total quality (Goldschmidt, 1999). It connects not only the quality of the question to be answered, the analytical quality reached, and the usefulness of the answer acquired, but also the patient's context and the physician's perceived ability to interpret and apply laboratory data. The post-analytical phase, like the pre-analytical process, can be divided into two parts: one that takes place in the laboratory and another (post-post-analytical) in which doctors receive, analyze, and react to laboratory results.

The laboratory's post-analytical procedures include verifying laboratory results, entering them into the laboratory information system, and communicating them to clinicians in a variety of ways (particularly by producing a report and making any necessary oral communications about "alert" or panic results). The most prevalent mistakes in this step, accounting for 18.4-47% of total laboratory errors, are erroneous validation, results that are delayed, not reported, or sent to the wrong providers, and incorrect results reported because of post-analytical data entry and transcription errors (Astion et al., 2003; Plebani & Carraro, 1997).

Manual test validation is a time-consuming process with significant inter-individual variance; also, it slows the laboratory's response to the clinic, resulting in delays in the diagnostic and treatment processes. This validation procedure can be automated; various automated validation methods with acceptable sensitivity and specificity have been developed and implemented in clinical laboratories (Oosterhuis et al., 2000; Valdiguié et al., 1992). However, it has yet to be demonstrated that validation methods help clinical laboratories reduce errors, hence increasing patient safety and outcomes. This is due to the challenges in conducting longitudinal studies with a design that allows for the detection of true errors and comparisons to historical error rates.

Validation systems, on the other hand, may be regarded valid "preventive action. Another well-known source of post-analytical issues is inter-laboratory

variability and reference interval inaccuracy (Klee, 2004; Zardo et al., 1999). Reference intervals for healthy and ill populations are useful benchmarks for clinical interpretation of laboratory test results. The use of varied, often incorrect, reference ranges can have a significant impact on the clinical interpretation of laboratory results, resulting in errors in clinical decision-making (Zardo et al., 1999). The development and publication of the laboratory report is the most important phase in post-analytical operations because its format, content, and communication have a considerable impact on physicians' interpretation and use of laboratory results.

The use of information technology in increasing the reliability and security of results reporting is well acknowledged. The requirements for information technology in laboratory medicine now extend far beyond the provision of purely analytical data to include essential components of data communication, including the notification of results that fall within established critical or alert intervals (R. Jones & O'Connor, 2004). The potential function of interpretative comments in enhancing patient outcomes has sparked a great deal of curiosity. Guidelines for providing interpretative comments have been released (Marshall & Challand, 2000) and schemes for grading comment quality have begun (Vasikaran et al., 2002). The results show that interpretation supplied by laboratory experts with insufficient experience can be risky, emphasizing the need for improvement in the current level of interpretation (M. Laposata, 2004; Lim et al., 2004).

In the post-analytical phase, which occurs outside of laboratory control, the clinician receives, examines, and evaluates the data before making a decision based on information from the laboratory and other sources. There is evidence that laboratory information is underutilized: according to a recent investigation, 45% of the findings for urgent laboratory tests sought by one hospital's Emergency Department were never accessible or were received far too late (Kilpatrick & Holding, 2001). Furthermore, several errors can occur at this point, as admitted by some clinicians while filling out questionnaires (Stroobants et al., 2003), but difficulties can arise at the laboratory-clinician interaction.

In fact, the laboratory's results may not contain all the information required by the clinician; the laboratory report may even include information that the clinician finds redundant or irrelevant. It has also been stated that the implementation of new and sophisticated tests, such as genetic testing, may complicate medical care, influencing the interpretation and clinical relevance of new and promising laboratory findings. Laposata and colleagues have demonstrated the utility of a laboratory interpretive service based on a pathologist's written, evidence-based, patient-specific interpretation that automatically accompanies the results of complex laboratory testing panels in several areas of laboratory medicine (Dighe et al., 2001; Kratz et al., 2001; M. E. Laposata et al., 2004). The basis of this service is the substitution of individual test requests by doctors with clinical questions, the use of reflex testing to improve test selection accuracy, and the provision of patient-specific narrative interpretations of test findings. A survey completed by the same organization found physician

satisfaction in over 80% of responses and a considerable reduction in test-ordering errors per request after 2.5 years of service (M. E. Laposata et al., 2004).

Causes of errors in medical laboratories

A study by Grover and Gadhavi focused on identifying and analyzing pre-analytical errors in venous specimen handling within medical laboratories over a 12-month period, recording 180 errors in total. These errors were categorized based on their occurrence within the pre-analytical phase. The most frequent error, accounting for 30% of cases, was improper timing of specimen collection. This typically resulted from patients not fasting or improperly preparing before specimen collection. Hemolyzed and clotted specimens were the second most common issue, comprising 24% of errors. These were mainly attributed to handling issues during specimen preparation, particularly impacting hematology and coagulation tests. Additionally, 19% of errors involved improper request forms, often missing essential details like patient age or specific test instructions. Delays in specimen transport constituted 8% of the errors, with transport delays compromising specimen integrity and potentially affecting test results. Incorrect patient identification and labeling accounted for 7% of errors, posing a risk of inaccurate test outcomes. Another 7% were related to insufficient specimen volumes, a common challenge when collecting samples from pediatric or debilitated patients. Finally, 5% of errors arose from improper tube collection, such as using incorrect tubes, which could disrupt accurate test analysis. The study concluded that although pre-analytical errors significantly impact diagnostic accuracy, they are preventable. Key recommendations included establishing standardized protocols, providing clear patient preparation instructions, and implementing technological solutions like barcoding for more reliable patient identification. Consistent education and competency assessments for laboratory staff, along with improved protocols for specimen handling and transportation, were also emphasized as essential strategies to reduce these errors (Grover & Gadhavi, 2024).

Another study by Guimarães conducted at a university hospital laboratory in Porto Alegre aimed to identify common causes of pre-analytical errors leading to the rejection of blood samples. Out of 77,051 blood samples collected, 441 (0.57%) were rejected due to pre-analytical issues. The most frequent cause of sample rejection, responsible for 43.8% of cases, was the presence of clots, particularly affecting samples collected in tubes with anticoagulants such as EDTA. This issue was attributed to inadequate mixing of the sample, which is especially problematic in pediatric units where venous access may be challenging. The second leading cause, comprising 24% of rejected samples, was insufficient sample volume, predominantly observed in pediatric and neonatal patients. Hemolysis was the third most common issue, affecting 17.9% of samples. Other causes, including misidentification, incorrect tube selection, lipemia, improper sample-to-additive ratios, and icteric samples, contributed to a smaller percentage of rejections (Guimarães et al., 2012).

Another study by Szecsi and Ødum on error tracking in a clinical biochemistry laboratory identified key causes and frequencies of errors over a one-year period. It found that out of 1189 errors reported, the vast majority (81%) were pre-analytical, primarily due to human mistakes, which accounted for 82.6% of all errors. Only 4.3% were technical issues, with the rest being analytical (10%), post-

analytical (8%), or service-related (1%). Errors were common when non-technicians performed tasks, with general practitioners and clinical wards contributing significantly to pre-analytical errors. Identification errors occurred often with blood samples collected by non-laboratory staff, leading to patient misidentification incidents. Haemolysis, largely due to human error or improper handling, dominated the interference errors. The study emphasizes the importance of structured error recording and highlights how a relational database can be essential in managing and analyzing errors to enhance laboratory workflow and safety (Szecsi & Ødum, 2009).

Another study by Schultz conducted in the Laboratory Medicine Department at the University Hospital of Verona investigated pre-analytic errors over one year, with 3154 errors identified among 423,075 blood samples. Most errors (0.82%) were from inpatient samples compared to outpatients (0.37%), with hemolysis, insufficient volume, and clotting being common issues. Errors in specimen identification, use of inappropriate containers, and contamination were also noted, with variations between inpatient and outpatient collections. Hemolysis was the predominant error in clinical chemistry and immunology testing, while insufficient volume and clotting issues were more frequent among inpatients. These results highlight the need for improved error-tracking and quality management in pre-analytic laboratory phases to reduce errors and improve patient outcomes (Schultz et al., 2006).

Steps to improve & Recommendations

In recent years, various suggestions and standards have been produced for the pre-analytical phase (Guder et al., 2000). The German Society for Laboratory Medicine's working committee on pre-analytical errors has offered extensive recommendations on the quality of diagnostic specimens, as well as the handling of hemolytic, icteric, and lipemic specimens (Narayanan & Guder, 2001).

International standardization organizations, such as ISO:6710, have established standards for the kind and concentration of anticoagulants to be used in venous blood specimens (ISO 6710:2017(En), Single-Use Containers for Human Venous Blood Specimen Collection, n.d.).

The Clinical and Laboratory Standards Institute (CLSI) issues guidelines on parts of the preanalytical phase to meet the demand for quality control and standardization in laboratory testing (Narayanan, 2000).

Steps:

1- To begin, develop clear and established processes for specimen collecting, handling, and transportation in the specimen collection manual. This document provides a basis for developing ways to identify and control this crucial part of laboratory quality throughout the preanalytical phase of testing. Laboratory personnel must follow the standardized protocols described in the specimen collecting handbook to understand the importance of these processes in preserving laboratory quality and patient safety.

2- Provide patients with explicit instructions on how to prepare for specimen collection, such as fasting overnight, refraining from exercise and stressful activities the night before and soon before blood collection, and foods and drugs to avoid (Narayanan, 2000).
3- The pre-analytical Quality manual should address posture during blood collection, tourniquet application length, time of blood collection to avoid diurnal effects, and specimen collection order (Narayanan & Guder, 2001).
4- Specimen processing, transportation, and storage conditions should be explicitly defined according to international norms (Narayanan & Guder, 2001).
5- Continuing Education - Laboratory staff should participate in frequent educational competency exams, both written and observational, which allow them to identify and correct faults (Lippi et al., 2006).
6- Vacutainers and the use of an evacuated tube system will help to overcome mistakes in specimen volume and anticoagulant use (Sciacovelli & Plebani, 2009).
7- Prompt carry - Transport staff are trained to carry specimens to the appropriate lab as soon as possible after collection, while maintaining optimal temperature conditions, to eliminate errors caused by delays.
8- The use of barcode scanners for patient identification will provide accurate identification while reducing any human errors (Chawla et al., 2010).
9- Implementing and monitoring preanalytical quality indicators, as well as conducting regular clinical audits, can help to identify and address preanalytical problems (Bonini et al., 2002).

Conclusion:

Pre-analytical errors in medical laboratories are a significant concern, but they are largely preventable through careful attention to specimen collection protocols, patient preparation, staff training, and technological interventions. By adhering to standardized practices, implementing error-tracking systems, and fostering a culture of continual education and quality control, laboratories can enhance the accuracy of diagnostic tests and improve patient outcomes.

Recommendations

- Establishing and enforcing standardized protocols for specimen collection, handling, and transportation to minimize errors due to human factors.
- Providing patients with clear, easily understandable instructions regarding fasting, medication, and preparation requirements before specimen collection.
- Implementing barcoding systems for accurate patient identification to reduce misidentification and labeling errors.
- Automated systems can also help ensure the correct tube is used for each test, and that specimen volumes are adequate.
- Ongoing education and competency assessments for laboratory staff are essential. Non-laboratory personnel (e.g., general practitioners, clinical staff) often contribute to errors, so training across all staff is crucial.

- Structured error tracking and relational databases can help monitor and analyze the causes of errors, improving laboratory workflow and safety. Laboratories should ensure that errors are logged in detail to identify patterns and implement corrective measures.
- Ensuring that specimens are transported promptly and maintained under optimal conditions, including temperature controls, to avoid degradation.
- Regular audits and adherence to international standards (e.g., ISO:6710) for specimen handling and quality control procedures can further reduce pre-analytical errors.

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