RESEARCH ARTICLE

J Bras Patol Med Lab. 2024; 60(1): 23-30.

10.1900/JBPML.2024.60.01.004

Evaluating the efficacy of automated systems in Blood Sample Analysis

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Abstract

This study focuses on accuracy, efficiency, and dependability while methodically evaluating the efficacy of automated methods in blood sample analysis. Examined are several aspects such as accuracy, sensitivity, specificity, and calibration stability to determine how well the system performs in terms of accuracy and consistency. A comparison with manual techniques, speed and throughput considerations, and an analysis of reproducibility through intra- and inter-assay variability are all part of the assessment process. For measuring the research used smart PLS software and generate result included descriptive statistic, correlation coefficient also that present smart PLS Algorithm model between them. The practical execution of user interface design, convenience of use, and training needs is assessed, and the correctness of the system is continuously ensured by quality control procedures such as internal and external proficiency testing. Cost-effectiveness factors include consumables, maintenance, and total cost of ownership. Data security, regulatory compliance, and interaction with laboratory information systems. Healthcare professionals and laboratory managers can make well-informed decisions about the adoption and implementation of automated systems in blood sample analysis by consulting the thorough evaluation provided in this study, which offers insightful information about the overall effectiveness of these systems. Overall result founded that significantly relation between them. The results of this study have the potential to improve the effectiveness and dependability of diagnostic procedures in contemporary healthcare settings

Keywords: Efficacy (EE), Automated System (AS), Blood Sample Analysis (BSA)

Introduction

Human blood is an important tool and method for the identification of different individual characteristics such as type of blood, antigens, disease presence, and others. However, there are traditional systems for blood tests which led to more time consumption, less accuracy, and more risk of error as well. But with the advancement of medical science and artificial intelligence, we came to know an automated system for blood testing that is more reliable as compared to previous less accurate traditional methods [1]. Nowadays we are using fully automated and computerized systems in the laboratory which gives quicker response in less time and also enables a smooth Workflow from the laboratory because of the swift pace. In medical science, more than 80% of diagnosis is done by using blood samples. Therefore, we can say that blood samples are central to the diagnosis of any disease in patients. Because of the importance of blood samples, these tests must be carried out and analyzed properly for effective and accurate results[2].

In laboratory automation, science, and technology have developed and promoted such robotics which has transformed the normal working of people in the laboratory. Now such automated robotics are introduced in laboratories which require less time and can work equal to more to human intelligence in an accurate way. One of the most important types of robots that are commonly used in gathering blood samples are auto samplers which can provide samples for analysis by analytical devices[3]. The second type of robots are mobile laboratory operators and remote-controlled laboratories. This robotics can perform analysis in a short period for pharmaceutical purposes. The other type of robot are plate readers, which can detect biological samples with more accuracy.

A kind of fully automated laboratory system has been introduced recently, which is named Tempus600. This system can transport blood samples [4]. By using this kind of system, manual work is reduced. It is concluded by medical science that most blood diseases are spread by manual work at hospitals by medical staff but by using these automated systems, there is a reduced risk transferring of blood diseases from one patient to another. This Tempus 600 can provide a direct route from collecting samples from the ward to the lab directly and is also able to store data in electronic form[5].

In the past, as we know there were many chances for data loss or data misuse of patients because of manual data collection and data storage but because of automated systems, now data can be collected and stored in the form of electronic signals in small chips. There is a direct line mechanism that is followed by this system that shows no prejudice in any case. In this way, waiting time for patients is also reduced [6]. The other robot systems are venipuncture robots which use IR infrared radiation and also ultrasound radiation in the form of imaging to localize the exact location of blood vessels in the body to collect blood samples. Some miniature robots can place the needle in the center of a blood vessel in a correct and suitable position[7].

Another important system is used as an analyzer for micro centrifugal blood separation and analysis in which the analyzer is made up of a small acrylic chip that can handle the sample and then centrifuge this blood sample to quantify white blood cells in blood. In this analyzer, a small centrifuge is used to spin that acrylic chip at high speed, which separates cell components from plasma. One of the benefits of these chips is that they are single-use disposable chips which reduce the risk of transferring blood diseases[8]. With the advancement and achievement of automated systems in Blood Sample Analysis, medical science and artificial intelligence have developed automated blood banks that are automated and computerized in relevant to blood donation. These automated systems can run

First submission on 28/02/2023; accepted for publication on 09/01/2024; published on 19/01/2024

important tests for diseases such as HIV, hepatitis, syphilis, and others. These systems can auto-determine the blood type and can also cross-match donor units. The other aspect of automated systems in the laboratory is the use of micro-sampling technology. In this technology, smaller volumes of samples are used in dry form to analyze drug and chemical exposure in that particular blood. This technology helps to study and analyze the composition of blood samples [9, 10].

The other important automated technology is real-time monitoring with lab on a chip, which is efficient enough to handle very small amounts of fluids for analytical purposes. The other important analyzer is an automated hematology analyzer which can swiftly analyze the blood sample for counting blood cells in a blood sample. It can count red blood cell counts, white blood cells, the number of platelets, the concentration of hemoglobin, and other indices as well. Nowadays rapid diagnostic test kits are introduced which are fully automated and can rapidly analyze blood samples. These types of test kits can be used for evaluating the intensity and severity of particular diseases, estimating the intensity of prognosis, monitoring the exact course of diseases, to selecting appropriate drugs for adjusting therapy[11].

All of these aspects effectively explain the importance of automated systems in Blood Sample Analysis. There are many benefits of such systems such as swift response, data storage, accurate results, better Workflow, and others. All of these aspects explain the importance of artificial intelligence in laboratories for blood sample analysis. But there are also some problems which are associated with using automated systems in Blood Sample Analysis. The first problem is that the cost of automated systems is very high which makes it less accessible to the common man[12].

The other problem is that it needs highly skilled professionals to use these computer-based automated systems for blood analysis which eventually increases the cost of analysis done by using automated systems. Thirdly, because it is based on computer systems thus we can confront computer-based errors in a few cases. The most important problem is that the increasing use of automated systems is prevailing in society which can increase unemployment in society and more dependence on computer systems for normal working as well[13, 14].

Research Objective

The main objective of this study is to understand the use of automated systems in Blood Sample Analysis. This study has effectively explained the benefits of using artificial intelligence in the laboratory for blood analysis. This system has also effectively explained the problems which are associated with the use of automated systems in Blood Sample Analysis. The research determines that Evaluating the efficacy of automated systems in Blood Sample Analysis.

The research divided into five specific sections first portion represent that introduction the second section describe that literature review the third portion represent those methods of research. The fourth portion present results and description also that last section summarized overall research study and present some recommendations about topic.

Literature Review

Researchers claim that the assessment of individual protection using an antibody-based protection system is made by detecting the serum assay of SARS-CoV-2.the serum collected from patients is detected using the MNT that determines the level of neutralizing antibody in the serum. The test results indicate that the level of Nabs is higher in older patients. Smart algorithms are used in laboratories to assess the immunity response in patients recovering from SARS-CoV-2 [15].

Studies suggest that the rate for exploring biomarkers of noninvasive nature is increasing at an exponential rate. the presence of biomarkers in patients with tumors is observed through their blood samples. The DNA and bio fluids of the tumor patient are taken, and the presence of biomarkers is identified using commercial kits. The most commonly used commercialized kits include magnetic and column-based kits[16].scholars explain that various evaluation methods are used in the medical field for classifying the severity of acute leukaemia.

To effectively improve the criteria for evaluating leukaemia samples, the MCDM analyzing technique is used in various evaluation processes[17].Researchers predict that diseases related to the bloodstream require the use of mRDTs for their proper screening. The mRDTs is a test-based methodology that diagnoses infections of the bloodstream. By combining the strategic mDRTs with ASP, the process of identifying bloodstream-related diseases becomes easier. The stream disorder in patients detected through the combined strategies of mDRTs along with ASP improves patients' quality of life. The use of strategic ASP in diagnosing bloodstream disorders holds importance as it results in ICERs [18]. Scholars' studies highlight that using infrared spectroscopy helps identify the biological specimen. Screening several disorders is made possible using the advanced technique of inferred spectroscopy. The process of clinically driven decision-making is improved by the use of infrared spectroscopy in the detection process of cancer-related biological compounds. Infrared spectroscopy has great application in the medical field for studying various specimens [19].studies predict that one of the major causes of mortality is because high prevalence of bloodstream disorders.

The BSI-affected patients are resistant to treatment procedures because of the presence of antimicrobial pathogens that are resistant to various drugs. To identify the antimicrobial resistance in patients, the blood cultures of patients are tested using the Accelerate Pheno System along with AST. The BSI patients having gram-negative pathogens in the bloodstream are effectively identified using the most reliable diagnosing system, which is the Accelerate Pheno System [20]. Scholars show that using an intelligence-based diagnosing system helps manage infectious disorders. the management of viral infection is made possible using the biosensing system. diagnosing the infection site is done using the IoMT-based sensor in diagnosing procedures. personalized treatment is provided to the patients using the IoMT-based biosensing treatment process [21].

Studies explain that in cancer patients, the metastasis cancer cells shedding allows the cancer cells to float in the bloodstream. These cancer cells floating in the bloodstream are termed CTCs. the detection of CTCs in the bloodstream is used as an early diagnosis technique for cancer [22].studies elaborate that mechanical ventilation causes weaning in ICU, creating problems for patients. The MV problem results in the onset of complicated medical issues. reducing the MV is a clinical procedure. Using AI technology in a based approach for managing the MV process holds immense importance [23].studies claim that thick blood samples from the affected patients detect the presence of malaria. Smartphone technology is employed widely in identifying the presence of malaria parasites through blood samples.

The smartphone technology used for detecting malaria parasites in blood samples works on deep neural-based algorithms [24].researchers highlight that microRNA is present in the bloodstream of patients affected with a disease condition. The microRNA acts as a biomarker for onseting disease conditions in patients. profiling of microRNAs is made using the NGS tool [25].Several scholars explain that blood samples are collected through safe and painless techniques. Using a capillary blood collection device helps collect blood samples through a painless method.to use this blood-collecting device, minimal medical training is required [26].

Moreover, heart-related diseases are detected using ANN-based systems. the DNN approach improves the process of detecting diseases related to the heart. the AI-based models are highly specific for determining the precise information related to any disease condition [27].studies reveal that the most expensive assay analysis is LFAs. the tests of LFAs are highly expensive as LFAs show high sensitivity. the sensitivity of LFAs can be improved by using sustainable methodologies. using the right and optimized approach for LFAs test-based identification is very critical [28].various scholars' studies show that the bloodstream is one of the main reasons behind a large number of worldwide deaths. The microbiological-based diagnosing procedure is carried out using the bloodstream samples [29].

The microbial identification process from the blood sample is enhanced using molecular detection methods. Different molecular methodology-based technology for assessing the blood samples provides different amplified results. The process of managing infections in patients is possible using molecular methodologies. after diagnosing the mechanism behind the antimicrobial activity in a specific blood sample, effective antimicrobial therapy is given to the patients [30]. Furthermore, the approach to testing DBS holds immense significance for promoting the clinical practices associated with TDM.

The DSBS methods are developed by getting validation from the therapeutic drug monitoring system. TDM aims to improve the process of micro-sampling [31].scholars studies predict that using individualized therapy for treating TBI is essential for maintaining the health of intensive care unit [32].Researchers studies predict that CTCs in the bloodstream are basically the sloughed-off tumour cells. Understanding the circulation of CTCs in blood aids in the process of identifying the cancer type. for sequencing the CTCs, the use of single-cell sequencing technique is made by researchers working on CTCs. this sequencing technique reveals the details about the nature of CTCs [33].

Furthermore, in most medical intensive care units, conservation strategies are adopted for conserving blood samples of patients. Blood sample conservation strategies effectively reduce the blood transfusion process [34].also, using the microneedle-associated devices helps extract the fluids for analysis purposes These microneedle devices have high efficacy in treating various diseases. The drug analysis process uses these microneedle devices [35, 36].

Requirement of Blood Sampling

Analysis of blood is a crucial step in medical diagnostics as it helps enhance the quality of healthcare services by providing insights on infection detection, dealing with chronic diseases, risk assessment for cardiovascular factors, organ function and assessment, screening of cancer, and analysis of blood clotting factors, etc. Regular blood analysis has been declared essential by physicians for the maintenance of health and effective management of medical conditions.

Automated Blood Sampling Systems

The analysis of blood using systems that can operate automatically involves using carefully designed instruments and modern technologies to upsurge the process of blood sample examination. These types of systems are actively efficient in clinical analysis laboratories and play a vital role in providing fast, precise, and dependable information on diagnosis.

The steps involved in the automatic blood analysis techniques involve sample collection, identification, barcoding, handling, and further required analysis like haematology, immunoassay coagulation, etc. These systems are known to perform various tests, e.g., immunoassays, routine blood tests, chemistry of blood analysis, etc. Following are some types of automated systems currently being used for the analysis of blood samples.

Analyzers Related to Laboratorial Assessments

These analyzers are modified to measure various components of a chemical nature present in the blood, i.e., enzyme concentration, electrolytes, glucose cholesterol, etc. These instruments use immunoassay techniques, colourimetric methods, enzymatic additions, etc.

Analyzers Related to Blood Examination

Blood Bank Analyzers are known to develop automatic information on blood cross-matching, typing, and infectious disease screening, which is necessary for performing safe blood donations. Also, the blood transfusion process is made efficient and safe by using these techniques.

Another important type of blood-related analyzer is the haematology analyzer, which is known to measure the components of blood automatically, i.e., white blood cells, red blood cells, and platelets. They give information on cell size, morphology counts, etc., to help diagnose conditions such as infections, anaemia, and other blood-related disorders. Similarly, Blood Gas Analyzers are a class of analyzers that work as automatic systems for the measurement of gases like CO_2 and O_2, which in turn help maintain the pH levels of blood samples. These types of analyses are important in managing patients' health, which is under critical care, and offer instant information on metabolic and respiratory disorders. Immunoassays are another famous class of detectors that can automatically detect specific blood components involving hormones, proteins, blood antibodies, antigens, and other molecules of importance.

Analyzers Related to Blood Cells and Coagulators

A blood cell automatic analyzer deals with the rate at which blood cells settle in a blood column in the laboratory. If an increased level is found, then it indicates underlying inflammatory conditions. These analyzers automatically assess the coagulation parameters and factors involved in blood clotting. They are important in dealing with bleeding disorders, anticoagulant therapy, and risk assessments for diseases like thrombosis. Also, some laboratories use automated systems to perform pre-analysis of the blood samples involving centrifugation and categorization of samples.

Smart PLS Algorithm Model:

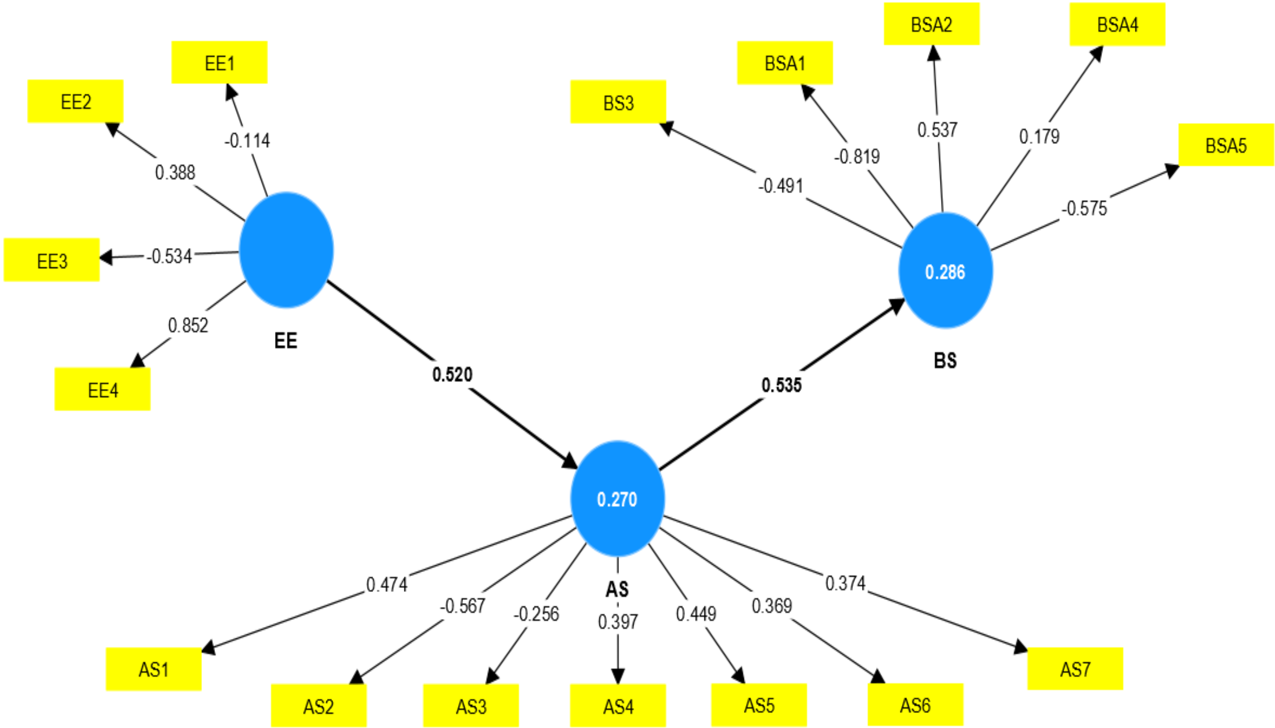

Figure 1

The above model represents the smart PLS Algorithm model related to the EE, AS, and BS. The EE shows that -0.114, 0.388, -0.534 and 0.852 present negative and positive relations. The AS describe that 47%, 56%, 25%, 39%, 44%, 36% and 37% values of each indicator related to them. similarly, EE shows a 52% positive link with AS, and BS shows a 53% positive and significant link.

Descriptive statistic

Table 1

Name	No.	Mean	Median	Scale min	Scale max	Standard deviation	Excess kurtosis	Skewness	Cramér-von Mises p value
EE1	0	1.367	1.000	1.000	3.000	0.523	-0.086	1.005	0.000
EE2	1	1.510	1.000	1.000	3.000	0.576	-0.554	0.621	0.000
EE3	2	1.469	1.000	1.000	3.000	0.575	-0.329	0.788	0.000
EE4	3	1.673	2.000	1.000	3.000	0.619	-0.607	0.364	0.000
EE5	4	1.469	1.000	1.000	2.000	0.499	-2.070	0.127	0.000
AS1	5	1.551	2.000	1.000	3.000	0.537	-1.139	0.198	0.000
AS2	6	1.694	2.000	1.000	3.000	0.613	-0.585	0.303	0.000
AS3	7	1.449	1.000	1.000	3.000	0.537	-0.806	0.618	0.000
AS4	8	1.612	2.000	1.000	4.000	0.664	1.879	1.078	0.000
AS5	9	1.673	2.000	1.000	4.000	0.682	1.331	0.931	0.000
AS6	10	1.653	2.000	1.000	4.000	0.687	1.343	0.982	0.000
AS7	11	1.592	2.000	1.000	3.000	0.603	-0.589	0.496	0.000
BSA1	12	1.776	2.000	1.000	3.000	0.708	-0.945	0.361	0.000
BSA2	13	1.673	2.000	1.000	4.000	0.711	0.920	0.936	0.000
BS3	14	1.673	2.000	1.000	4.000	0.711	0.920	0.936	0.000
BSA4	15	1.551	2.000	1.000	3.000	0.574	-0.694	0.463	0.000
BSA5	16	1.551	1.000	1.000	3.000	0.672	-0.394	0.849	0.000

The above result shows that descriptive statistical analysis describes each variable's mean values, median rates, standard deviation values, skewness rates, and probability values, including independent and dependent variables. The EE1, EE2, EE3, EE4, and EE5 are all considered independent present whose mean values are 1.367, 1.510, 1.469, 1.673 and 1.469. These all show the positive average value of the mean. According to the result, its standard deviation values are 52%, 57%, 61%, and 49% deviate from mean values. According to the result, the overall minimum value is 1.000, and the maximum is 4.00.

The median rate is 2.000, respectively. The AS1, AS2, AS3, AS4, AS5, AS6 and AS7 are considered mediator variables according to the result mean values of 1.551, 1.694, 1.449, 1.612, 1.673, and 1.653. These all show positive average values of the mean. The standard deviation rates are 53%, 61%, 66%, and 68% deviate from mean values. Similarly, the BSA1, BSA2,3,4 and 5 5 are all factors considered dependent variables mean values are 1.776, 1.673, and 1.551. These rates present a positive average value of the mean.

The standard deviation rates are 70%,71%, 57%, and 67% deviate from mean values. The probability value of 0.000 shows that there is 100% significance between them.

Features

Assessing a number of variables to guarantee accuracy, efficiency, and dependability is necessary when evaluating the effectiveness of automated systems for blood sample analysis. There are some important things to think about:

1. Correctness:

• Sensitivity and Precision: Assess the system's capacity to deliver sensitive and exact outcomes. Sensitivity measures the system's capacity to detect analyte concentrations at low levels, whereas precision guarantees measurement consistency. • Specificity: Evaluate the system's capacity to precisely detect and quantify certain analytes free from interference from other blood components. • Comparison with Manual procedures: To verify accuracy, compare the automated system's results with the results of conventional manual procedures.

2. Viaput and Velocity:

• Turnaround Time (TT): Calculate how long an automated system takes to process a blood sample. Quick turnaround times are essential for effective healthcare workflows. • Sample Throughput: Determine how well the system can process many samples in a predetermined time.

3. The ability to replicate:

• Within- and Between-Assay Variability: Evaluate the system's capacity to provide reliable findings when using various operators or equipment (inter-assay) and analysing the same sample more than once (intra-assay). • Calibration Stability: To prevent results from drifting, ensure the automated system keeps its calibration stable over time.

4. Usability and User Interface:

• User-Friendly Interface: Consider how straightforward and user-friendly the system's interface is. This covers data entry, result interpretation, and programme navigation. • Training Requirements: Determine what degree of training operators need to utilise and troubleshoot the system efficiently.

5. Measures of Quality Control:

• Internal Quality Control (IQC): Assess how well the system uses internal QC processes to keep an eye on and preserve quality. • External Quality Assurance (EQA): Take part in external proficiency testing initiatives to verify the correctness of the system and compare findings with those from other laboratories. • Total Cost of Ownership (TCO): Consider not just the price of the initial purchase but also continuing costs like consumables, maintenance, and possible downtime.

7. Adherence to Regulation:

• Regulatory Approval: Verify that the automated system has obtained the required approvals from regulatory agencies and conforms with all applicable regulatory requirements. Evaluate the system's data security components to guarantee patient privacy and adherence to laws.

8. Using the Laboratory Information System (LIS) Integration:

• Interoperability: Assess how well the system integrates with current laboratory information systems to provide effective reporting and data management. By carefully evaluating these criteria, you may obtain a comprehensive understanding of the overall effectiveness of automated systems in blood sample analysis and make well-informed judgements about their application in clinical settings.

Correlation coefficient

Table 2(a)

	EE1	EE2	EE3	EE4	EE5	AS1	AS2	AS3	AS4	AS5	AS6	AS7	BSA1	BSA2	BS3	BSA4	BSA5
AS1	0.079	-0.117	0.088	0.112	0.177	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AS2	-0.413	-0.078	0.292	-0.156	0.069	0.016	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AS3	0.067	0.117	-0.088	0.073	0.051	-0.221	-0.078	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AS4	-0.060	0.304	-0.218	0.139	-0.005	0.027	-0.091	-0.084	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AS5	0.050	0.060	-0.025	0.183	0.331	0.101	0.054	-0.046	0.171	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AS6	-0.157	-0.068	-0.104	0.406	0.177	0.186	-0.107	-0.076	-0.161	0.063	1.000	0.000	0.000	0.000	0.000	0.000	0.000
AS7	-0.172	0.129	-0.036	0.244	-0.041	-0.062	-0.117	-0.253	0.267	0.023	-0.293	1.000	0.000	0.000	0.000	0.000	0.000
BS3	0.213	0.108	0.175	-0.381	-0.028	-0.117	0.239	0.010	-0.182	0.117	-0.023	-0.311	0.098	-0.130	1.000	0.000	0.000
BSA1	-0.053	0.081	0.159	-0.121	-0.164	-0.373	0.218	0.158	-0.012	-0.406	0.008	-0.215	1.000	0.000	0.000	0.000	0.000

Table 2(b)

	EE1	EE2	EE3	EE4	EE5	AS1	AS2	AS3	AS4	AS5	AS6	AS7	BSA1	BSA2	BS3	BSA4	BSA5
BSA2	-0.062	-0.092	-0.074	-0.057	0.432	0.151	0.098	-0.204	-0.009	0.243	0.144	0.117	-0.267	1.000	0.000	0.000	0.000
BSA4	0.006	0.014	0.082	0.104	0.237	0.207	0.190	-0.207	-0.028	0.199	0.226	0.001	0.053	0.291	-0.059	1.000	0.000
BSA5	-0.053	0.328	0.123	-0.058	0.142	-0.276	0.360	0.050	0.067	0.125	-0.116	0.102	0.432	-0.093	0.120	0.218	1.000
EE1	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EE2	0.191	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EE3	0.105	-0.107	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EE4	-0.386	0.124	-0.143	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EE5	0.121	0.090	0.228	-0.032	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The above result describes that correlation coefficient analysis is related to the dependent and independent variables. the BSA1,2,3,4,5 show some negative and some positive interrelation between them.

Efficacy of Automated Systems for Blood Sample Analysis

The efficacy of these automated systems is apparent in some aspects and shows numerous advantages over outdated, labor-intensive blood analysis methods.

Providence of Reliability

Automatic systems can ensure the reproducibility of the clinical blood analysis by providing consistent results based on the standardization processes.

These sorts of consistent results are necessary for monitoring trends in patients' health, studies of a longitudinal nature, and maintenance of consistency in healthcare centers.

Validity of System

Automatic blood analysis systems are designed to reduce the error caused by human handling and thereby reduce the rate of inexactitudes that can occur due to mismanaged handling of blood samples. The precision of instruments along standardized processes helps to increase the overall rate of accuracy of analysis.

Results at Higher Pace

Recent techniques involved in automatic blood sampling can process numerous blood samples in a shorter time slot than the long awaiting time slots required by manual setups. This pace increase helps the caregivers make immediate decisions and take timely measures.

Efficacious Outcomes

Modern automatic systems are considered important as they rationalize the workflow of a clinical laboratory by providing continuous results by reducing multiple steps of blood analysis into a single efficient step. Moreover, the active time of laboratory staff and interventions of a manual nature are reduced.

Regulation of Resources

Resources (reagents) can be optimized by carefully dispensing and measuring required reagent amounts. This results in minimizing laboratory wastage and can add to the effectiveness and productivity of operations occurring in the laboratory.

Broader Variety of Tests

Different automated systems allow laboratories to offer an expanded menu of diagnostics and a range of tests without any need for excessive instrument and staff duties. This diversity allows the clinical laboratories flexibility in valuable requirements for particular blood testing.

Sample Trailing

The errors of sample mix-ups can be inhibited by using automatic systems that allow caregivers to regulate and manage data by elevation and traceability of risk factors. Laboratory systems that contain information on patient's health can be integrated easily by providing storage and easy data transfer.

Quality Maintenance

The systems that are bound to give information on quality control allow the development of helpful controlling measures that can boost the performance of instruments and the precision of outcomes. The quality assurance automatic systems can maintain the reliability of testing in laboratories. In this way, blood testing through automated systems has done wonders in medical and laboratory functioning by increasing the efficiency and reproducibility of blood sampling results. But should be taken into consideration that these automatic systems require calibration and preservation. Moreover, certain assays cannot be performed automatically and require manual methods. Therefore, regular training of laboratory staff members is necessary to use such modern systems effectively.

Conclusion

In summary, assessing automated systems for blood sample analysis is a complex procedure requiring careful consideration of several variables. The effectiveness of these systems depends on their capacity to deliver precise, consistent, and fast outcomes while upholding regulatory compliance and user-friendliness. The reliability of automated systems primarily depends on accurate and exact measurements, which are shown by internal/external quality control measures and compared with manual techniques. Speed and throughput are important factors in healthcare processes because they enhance operational efficiency. The research determines that Evaluating the efficacy of automated systems in Blood Sample Analysis. For measuring the research study used smart PLS software and generate informative results included descriptive statistic, correlation coefficient analysis also that explain the smart PLS Algorithm model between them. For a system to function consistently and dependably over time, it must be able to manage a large sample volume and maintain calibration stability. To guarantee that laboratory personnel can run the system efficiently with little training, user interface design and simplicity of use are essential. Monitoring and preserving the correctness of outcomes depends heavily on internal and external quality control methods. The system's overall cost of ownership and cost-effectiveness should be weighed against the advantages it offers the lab. Ensuring patient confidentiality, fulfilling legal obligations, and smoothly integrating the automated system into current processes depend on compliance with regulatory standards, data security, and interaction with laboratory information systems. Overall research concluded that direct and significant relation between them. To sum up, a thorough assessment that considers quality control, speed, accuracy, repeatability, user-friendliness, cost-efficiency, and compliance is required to ascertain the overall success of automated systems in blood sample analysis. By enabling medical practitioners and laboratory managers to make well-informed choices regarding adopting and applying these technologies in clinical practice, these assessments eventually improve the effectiveness and dependability of diagnostic procedures.

Reference

[1] E. N. Bodine and M. V. Martinez, "Optimal genetic augmentation strategies for a threatened species using a continent-island model," *Letters in Biomathematics,* vol. 1, no. 1, pp. 23-39, 2014, doi: https://doi.org/10.30707/LiB1.1Bodine.

[2] Y. Toki *et al.*, "Reticulocyte hemoglobin equivalent as a potential marker for diagnosis of iron deficiency," *International journal of hematology,* vol. 106, pp. 116-125, 2017.

[3] H. Miyachi *et al.*, "Monitoring of inhibitors of enzymatic amplification in polymerase chain reaction and evaluation of efficacy of RNA extraction for the detection of hepatitis C virus using the internal control," 1998.

[4] Y. Tian, "Frequency formula for a class of fractal vibration system," *Reports in Mechanical Engineering,* vol. 3, no. 1, pp. 55-61, 2022.

[5] S. D. Vieira *et al.*, "Autologous blood salvage in cardiac surgery: clinical evaluation, efficacy and levels of residual heparin," *Hematology, Transfusion and Cell Therapy,* vol. 43, pp. 1-8, 2021.

[6] J. Zhou, "Research on construction management risk assessment method of Pharmaceutical industries," *Journal of Commercial Biotechnology,* vol. 27, no. 3, 2022, doi: https://doi.org/10.5912/jcb1112.

[7] Y. Parisky *et al.*, "Efficacy of computerized infrared imaging analysis to evaluate mammographically suspicious lesions," *American Journal of Roentgenology,* vol. 180, no. 1, pp. 263-270, 2003.

[8] S. Shea, W. DuMouchel, and L. Bahamonde, "A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting," *Journal of the American Medical Informatics Association,* vol. 3, no. 6, pp. 399-409, 1996.

[9] D. Nörz *et al.*, "Pushing beyond specifications: evaluation of linearity and clinical performance of the cobas 6800/8800 SARS-CoV-2 RT-PCR assay for reliable quantification in blood and other materials outside recommendations," *Journal of Clinical Virology,* vol. 132, p. 104650, 2020.

[10] G. Lippi *et al.*, "Multicenter evaluation of the hemolysis index in automated clinical chemistry systems," *Clinical chemistry and laboratory medicine,* vol. 47, no. 8, pp. 934-939, 2009.

[11] A. Van Den Berg, C. L. Mummery, R. Passier, and A. D. Van der Meer, "Personalised organs-on-chips: functional testing for precision medicine," *Lab on a Chip,* vol. 19, no. 2, pp. 198-205, 2019.

[12] S. R. Morris, S. J. Little, T. Cunningham, R. S. Garfein, D. D. Richman, and D. M. Smith, "Evaluation of an HIV nucleic acid testing program with automated Internet and voicemail systems to deliver results," *Annals of internal medicine,* vol. 152, no. 12, pp. 778-785, 2010.

[13] H. Ceelie, R. D. Dinkelaar, and W. van Gelder, "Examination of peripheral blood films using automated microscopy; evaluation of Diffmaster Octavia and Cellavision DM96," *Journal of clinical pathology,* 2006.

[14] A. D. Baines, E. A. Eager, and A. M. Jarosz, "Modeling and analysis of american chestnut populations subject to various stages of infection," *Letters in Biomathematics,* vol. 1, no. 2, pp. 235-247, 2014, doi: https://doi.org/10.30707/LiB1.2Baines.

[15] G. Matusali *et al.*, "SARS-CoV-2 serum neutralization assay: a traditional tool for a brand-new virus," *Viruses,* vol. 13, no. 4, p. 655, 2021.

[16] R. J. Diefenbach, J. H. Lee, R. F. Kefford, and H. Rizos, "Evaluation of commercial kits for purification of circulating free DNA," *Cancer genetics,* vol. 228, pp. 21-27, 2018.

[17] M. Alsalem *et al.*, "Systematic review of an automated multiclass detection and classification system for acute Leukaemia in terms of evaluation and benchmarking, open challenges, issues and methodological aspects," *Journal of medical systems,* vol. 42, pp. 1-36, 2018.

[18] E. E. Pliakos, N. Andreatos, F. Shehadeh, P. D. Ziakas, and E. Mylonakis, "The cost-effectiveness of rapid diagnostic testing for the diagnosis of bloodstream infections with or without antimicrobial stewardship," *Clinical microbiology reviews,* vol. 31, no. 3, pp. 10.1128/cmr. 00095-17, 2018.

[19] K.-Y. Su and W.-L. Lee, "Fourier transform infrared spectroscopy as a cancer screening and diagnostic tool: a review and prospects," *Cancers,* vol. 12, no. 1, p. 115, 2020.

[20] M. Marschal, J. Bachmaier, I. Autenrieth, P. Oberhettinger, M. Willmann, and S. Peter, "Evaluation of the accelerate pheno system for fast identification and antimicrobial susceptibility testing from positive blood cultures in bloodstream infections caused by gram-negative pathogens," *Journal of clinical microbiology,* vol. 55, no. 7, pp. 2116-2126, 2017.

[21] S. Jain *et al.*, "Internet of medical things (IoMT)-integrated biosensors for point-of-care testing of infectious diseases," *Biosensors and Bioelectronics,* vol. 179, p. 113074, 2021.

[22] Z. Shen, A. Wu, and X. Chen, "Current detection technologies for circulating tumor cells," *Chemical Society Reviews,* vol. 46, no. 8, pp. 2038-2056, 2017.

[23] M. T. Kwong, G. W. Colopy, A. M. Weber, A. Ercole, and J. H. Bergmann, "The efficacy and effectiveness of machine learning for weaning in mechanically ventilated patients at the intensive care unit: a systematic review," *Bio-Design and Manufacturing,* vol. 2, pp. 31-40, 2019.

[24] F. Yang *et al.*, "Deep learning for smartphone-based malaria parasite detection in thick blood smears," *IEEE journal of biomedical and health informatics,* vol. 24, no. 5, pp. 1427-1438, 2019.

[25] A. M. Coenen-Stass *et al.*, "Evaluation of methodologies for microRNA biomarker detection by next generation sequencing," *RNA biology,* vol. 15, no. 8, pp. 1133-1145, 2018.

[26] T. M. Blicharz *et al.*, "Microneedle-based device for the one-step painless collection of capillary blood samples," *Nature biomedical engineering,* vol. 2, no. 3, pp. 151-157, 2018.

[27] L. Ali, A. Rahman, A. Khan, M. Zhou, A. Javeed, and J. A. Khan, "An automated diagnostic system for heart disease prediction based on ${\chi^{2}} $ statistical model and optimally configured deep neural network," *Ieee Access,* vol. 7, pp. 34938-34945, 2019.

[28] J. D. Bishop, H. V. Hsieh, D. J. Gasperino, and B. H. Weigl, "Sensitivity enhancement in lateral flow assays: A systems perspective," *Lab on a Chip,* vol. 19, no. 15, pp. 2486-2499, 2019.

[29] P. Turek, "Evaluation of the auto surfacing methods to create a surface body of the mandible model," *Reports in Mechanical Engineering,* vol. 3, no. 1, pp. 46-54, 2022.
[30] N. Peker, N. Couto, B. Sinha, and J. W. Rossen, "Diagnosis of bloodstream infections from positive blood cultures and directly from blood samples: recent developments in molecular approaches," *Clinical Microbiology and Infection,* vol. 24, no. 9, pp. 944-955, 2018.
[31] S. Capiau *et al.*, "Official international association for therapeutic drug monitoring and clinical toxicology guideline: development and validation of dried blood spot–based methods for therapeutic drug monitoring," *Therapeutic drug monitoring,* vol. 41, no. 4, pp. 409-430, 2019.
[32] E. Beqiri *et al.*, "Feasibility of individualised severe traumatic brain injury management using an automated assessment of optimal cerebral perfusion pressure: the COGiTATE phase II study protocol," *BMJ open,* vol. 9, no. 9, 2019.
[33] D. Lin *et al.*, "Circulating tumor cells: Biology and clinical significance," *Signal transduction and targeted therapy,* vol. 6, no. 1, p. 404, 2021.
[34] S. Keogh, S. Mathew, A. J. Ullman, C. M. Rickard, and F. Coyer, "What blood conservation practices are effective at reducing blood sampling volumes and other clinical sequelae in intensive care? A systematic review," *Australian Critical Care,* 2023.
[35] S. Ma, J. Li, L. Pei, N. Feng, and Y. Zhang, "Microneedle-based interstitial fluid extraction for drug analysis: Advances, challenges, and prospects," *Journal of Pharmaceutical Analysis,* vol. 13, no. 2, pp. 111-126, 2023.
[36] Y. Zheng, "The application of task-driven model in adult computer technology teaching in healthcare sector," *Journal of Commercial Biotechnology,* vol. 27, no. 5, pp. 50-66, 2022, doi: https://doi.org/10.5912/jcb1095.