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Factors Influencing the Quality of Medical Laboratory Services in Sawani bin Adam, Libya

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Abstract: Quality medical laboratory services are very important for effective healthcare delivery, as medical decisions depend on the accuracy and reliability of laboratory test results. In many developing countries, including Libya, laboratory quality management systems remain limited due to the structural and organizational challenges. This study aimed to assess the factors influencing the quality of medical laboratory test results and to evaluate laboratory service quality in Sawani bin Adam, Libya. A cross-sectional study was conducted from January to June 2024 across 22 medical laboratories. Data were collected from 208 laboratory staff using a questionnaire to gather data and identify factors affecting service quality. 100 blood samples from 20 healthy volunteers were analyzed in four local laboratories and one reference laboratory (Abu Salim Trauma Hospital). The findings showed no significant differences in most test results among laboratories, except for White Blood Cell (WBC) count. Most participants 80.8% were aged between 20–30 years, 63% were laboratory technologists and 86.5% worked in public laboratories. Notably, 61.5% of respondents reported that external quality assessment programs were not implemented. About half of participants indicated inadequate service quality, while 58.2% agreed about the absence of customer service management, mainly due to limited resources and poor management. The study identified many factors affecting to quality laboratory, including the lack of standard operating procedures, limited professional development, insufficient supplies, weak quality assessment systems, and inadequate safety measures. The implementing of international laboratory quality standards as part of national policy is recommended to improve laboratory quality and performance in Libya.

Keywords: Quality factors, Medical Laboratory Service, blood analysis. Swani bin Adam, Libya.

Introduction

Health is defined by the World Health Organization (WHO) as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [1]. Healthcare, conversely, is typically explained as the management of, responsibility for, or attention to the safety and well-being of another person [2]. The Libyan healthcare system comprises both public and private sectors. The public system is primarily funded by the government to ensure equitable access to health services and maintain free point-of-delivery care [3]. The public health system operates on three administrative levels: Primary Level. Consists of 1,355 primary health facilities (including units, centers, and polyclinics), which house various departments such as laboratories, radiology, and pharmacies. Secondary Level: Includes 75 general hospitals. Third Level**:** Comprises 22 specialized hospitals. The private sector supplements this with 157 inpatient facilities, 503 out-patient clinics, 2,254 pharmacies, and 426 laboratories [3].

Public healthcare services in many nations, including Libya, operate under significant constraints that impact service delivery, such as limited resources, restricted funding, high patient demands, and challenging health problems. The efficacy of the entire healthcare system structure is heavily dependent on reliable and accurate laboratory results [4].

A quality medical laboratory service is therefore an essential component of the healthcare system, required for accurate disease diagnosis and effective treatment planning [5]. Total Quality Management (TQM) is one established system used to implement quality service, which has been widely adopted by laboratories in countries such as the USA, China, and other developed nations [6]. In several less developed Asian countries (e.g., Bhutan, Bangladesh, Nepal), formal accreditation is often absent, while in India, accreditation remains voluntary, particularly within private medical laboratories [7].

Quality in healthcare is recognized as a complex, multi-dimensional, and subjective concept. Over 50 years ago, Donabedian defined healthcare quality as the application of medical science and technology in a manner that maximizes its benefit to health without correspondingly increasing the risk [8]. According to Schuster *et al*. (1988), good

healthcare quality involves providing patients with suitable services in a technically competent way, supported by effective communication, shared decision-making, and cultural sensitivity [9].

Quality control encompasses the approaches used to ensure the accuracy, consistency, and reliability of assays or tests within a medical laboratory. Quality assurance in medical laboratories specifically ensures that every step throughout the entire testing process is performed correctly, thus guaranteeing that medical decisions are made accurately and healthcare is provided effectively to the patient [10].

Materials and Methods

Study Area

The study was conducted within the municipality of Sawani bin Adam, located approximately 20 kilometers south of the capital city, Tripoli. The area is situated between latitude 32° 43' 03" N and longitude 13° 04' 35" E. It functions as a suburb of Tripoli, with an estimated population of about 57,000 people [11].

Study Design and Period

A cross-sectional analytical study was implemented utilizing designed and pilot tested questionnaires and also blood analysis to assess factors affecting the quality of medical laboratory services across both public and private laboratories. The study was carried out in the municipality of Sawani bin Adam from January to June 2024.

Study Protocol

The study protocol began with an initial step of visiting all functional medical laboratories in the Sawani bin Adam region, as well as the public Abu Salim Trauma Hospital laboratory, which served as a reference laboratory. A survey was conducted using a specifically designed questionnaire administered to 208 staff members that were actively performing bench work investigations and willing to participate in the study. The questionnaires were filled by the researchers to ensure understanding, honesty and accuracy. This survey aimed to evaluate the factors that impact the provision of quality services within these facilities. The collected data were subsequently analyzed to identify the laboratories most appropriate for the comparative blood sample testing component, ensuring they used similar equipment and testing methodologies. All participants involved in the blood sample collection portion of the study provided signed informed consent before sample collection procedures commenced.

Inclusion Criteria

- Participants aged 18 years or older who willingly provided signed informed consent to participate.
- Laboratory staff actively engaged in performing laboratory tests (manual or automated) within the selected laboratories.

Exclusion Criteria

- Any person exhibiting signs of illness or deemed too sick to safely participate in the study.
- Laboratory staff who were absent or on leave during the data collection period.

Blood Sample Collection

A total of 20 healthy adults (from both sexes) were included in the study as volunteers. 5ml Blood samples were collected at selected laboratories using five collection tubes per participant. The samples were immediately transported to the laboratories for a complete blood count (CBC) analysis. The data included in the comparison were the results for Red Blood Cells (RBC), White Blood Cells (WBC), Platelets, and Hemoglobin (Hb) readings.

To ensure consistency and comparability, all samples from a single participant were distributed simultaneously to the five participating laboratories in Sawani bin Adam and the Abu Salim Trauma Hospital reference laboratory. The analyses were performed using the equipment and techniques available at each respective facility, specifically identified as the Sysmex KX-21N, Mindray, and Beckman analyzers.

Laboratory Staff Questionnaire

The questionnaire component of the study included 208 staff members recruited from 13 public and 9 private medical laboratories. Data were collected using structured questionnaires that covered several key areas: personal demographic data, quality control protocols, equipment management, laboratory commodity management systems, human resource management, supervision practices, and identified challenges/ difficulties/ restraints.

Statistical Analysis

All collected data were coded, entered, and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 24. Descriptive statistics were used to summarize the socio-demographic characteristics of the participants and laboratory quality indicators. Frequencies and percentages were calculated for categorical variables, while means and standard

deviations were calculated for continuous variables.

The Chi-square (χ^2) test was applied to determine the association between categorical variables such as staff characteristics, quality control practices, equipment management, and the perceived level of laboratory service quality. For the comparison of hematological parameters obtained from different laboratories, including Red Blood Cells (RBC), White Blood Cells (WBC), Hemoglobin (Hb), and Platelets (PLT), one-way analysis of variance (ANOVA)was used to determine whether statistically significant differences existed among the laboratories. When significant differences were detected, Tukey'spost-hoc test was performed to identify the specific laboratories responsible for the variation. In addition, binary logistic regression analysis was conducted to identify the major factors associated with the provision of quality laboratory services. A p-value $\leq 0.05$was considered statistically significant for all statistical tests.

Ethical Considerations

Ethical approval was obtained from department of life science research committee before any data collection. Participation in the study was entirely voluntary. Only individuals above the age of 18 were enrolled. All study participants signed a written informed consent form after being fully briefed on the research objectives. Confidentiality was strictly maintained by using anonymous codes instead of names. Participants were informed of their right to withdraw from the study at any time without conditions or penalty.

Results

Overview of Data Collection

The study encompassed an evaluation of various quality indicators collected from 22 laboratories within the Sawani bin Adam municipality over a six-month period. These quality indicators were categorized into the three standard phases of laboratory workflow: pre-analytical, which concerns about personal skills, analytical phase that when analysis of samples take place, and post-analytical, which is about result reporting. A total of 208 medical laboratory employees participated by completing the questionnaires with the researcher presence. Also, 20 people participated in blood analysis by drawing 5 blood samples of 5ml from each person. 100 samples were collected at same time and transported to and analyzed in four pre-selected laboratories and the Abu Salim Trauma Hospital which used as reference laboratory (ISO certificated since 2008), all five laboratories use Sysmex brand equipment for blood analysis to ensure similarity and minimize manufacture differences. The findings from both the questionnaire responses and the comparative blood analyses are detailed below.

Socio-demographic Characteristics of Participants

Of the 208 respondents (table 1), the majority of staff members (n=170, 81.7%) were employed in public health institutions. The demographic distribution showed a predominantly female workforce (n=138, 66.3%). The average age of participants was 32 years, with the majority of respondents (n=168, 80.8%) falling within the 20–30 years' age group. Regarding qualifications, 131 participants (63%) were classified as highly trained professionals holding a Bachelor's degree in medical laboratory technology. The remaining 82 participants (38.5%) were certified medical laboratory technicians holding a diploma degree or relevant training course certificate.

Quality assurance practices and provision of laboratory services in Sawani bin Adam

Out of 208 participants there were 74.5% illustrated that their laboratories use a good documentation and about 71.1% of laboratory staff believe their laboratories adherence to the standard operating procedure. More than half of participants agree on absence of customer services management and no adequate equipment calibration and maintenance used. About 49% of respondents think their laboratories did not provide quality laboratory services (table 2).

Blood analysis results

The medical laboratory facilities provide services that help all other professionals in different departments and clinics in diagnosis, treatment, follow ups and monitoring of diseases. Haematology section in the laboratory performs various tests, including complete Blood Count (CBC), coagulation panels, blood morphology, blood film (BF) and erythrocyte sedimentation rates (ESR). In the present study all 100 blood samples from 20 participants (5 samples from each participant) were obtained at same time and tested for CBC analysis in five different laboratories. The red blood cells (RBC), white blood cells, haemoglobin (HG) and platelets (PLT) among CBC parameters were used for comparison in this study. The results of analysis are shown in next tables and graphs to figure out similarities and differences between laboratories results reported in table 3 and graphs 1, 2,3 and 4.

Factors Affecting Laboratory Service Quality

Binary logistic regression analysis was conducted to identify the major factors influencing the quality of laboratory services. The analysis revealed that staff training, equipment maintenance, and workload were significantly associated with the perceived quality of laboratory services (table 4). Laboratories with adequately trained staff and regular equipment maintenance were more likely to provide high-quality services compared with laboratories lacking these essential components.

Discussion. Reliable medical laboratory services are fundamental to the diagnosis and assessment of patient health and the provision of appropriate treatment [12,13]. Previous studies have identified numerous factors that influence the quality of laboratory services, including insufficient supplies, lack of staff motivation, resource shortages, high workload, inadequate training, poor equipment management, and the absence of robust quality assurance practices [14, 15].

The current study found that 81.7% of respondents were employed in public health institutions, with a female majority (66.3%) and a predominantly young workforce (80.8% aged 20–30 years). Educational attainment was high, with 63% holding a Bachelor's degree. Globally, and specifically within Libya, laboratory professionals in both public and private sectors often contend with high workloads within regulatory environments lacking sufficient quality control measures, clear job descriptions, or mandated continuing education and training. Baidoun and Zairi have emphasized that education, training, and motivation are critical drivers for the successful implementation of a quality management system, noting that untrained professionals increase laboratory system costs through inaccurate test results, which subsequently damage reputation and quality [16].

The comparative analysis of hematological test results demonstrated that the majority of laboratories produced comparable results for key hematological parameters, including red blood cells, white blood cells, and hemoglobin levels. This finding suggests a reasonable level of technical reliability among participating laboratories. However, significant differences were observed in platelet counts between some laboratories and the reference laboratory. Such discrepancies may arise from variations in instrument calibration, quality control practices, or technical procedures used during analysis.

Furthermore, observational data and survey results highlighted several critical factors influencing the quality of laboratory services and results. These issues must be prioritized by laboratory management to meet the requirements of implementing international quality standards, such as ISO 15189. Few laboratories in Libya have achieved international accreditation [17,18]; therefore, achieving accreditation to standards like ISO 15189 is essential for providing assurance of quality and competence.

Conclusion

The study concludes that the evaluated medical laboratories lack well-established quality management systems, formal staff recognition programs, and continuous education/training initiatives. The key factors identified as negatively affecting the provision of quality laboratory services were shortages of qualified staff and resources, insufficient management support, poor equipment management systems, high workloads, low staff motivation, the absence of effective communication systems, and generally weak quality control practices. Additional contributing factors included poor internal quality control (IQC) procedures, delayed result reporting times, and a lack of standardized job descriptions [19]. It is widely recognized that medical laboratory services are a vital component of the healthcare system. The implementation of a robust laboratory quality system will substantially improve the quality and reliability of services provided for disease diagnosis, treatment, and prevention [20, 21].

Overall, the findings of this study emphasize that improving laboratory service quality requires a comprehensive approach that addresses human resources, infrastructure, equipment management, and quality assurance systems simultaneously. Strengthening training programs, improving equipment maintenance systems, and promoting the adoption of international accreditation standards could significantly enhance the quality and reliability of laboratory services in Libya.

Table1. Socio-demographic characteristic of laboratory professionals working in medical laboratories in Swani bin Adam in Libya.

Variable		Frequency	Percentage (%)
Sex	Male	70	33.7
	Female	138	66.3
Age group	20-30	168	80.8
	31 -40	29	14
	41 -50	9	4.2
	51 -60	2	1
Education level	Diploma	77	37
	Bachelor	131	63
Working laboratory	Public	180	86.5
	Private	28	13.5
Laboratory discipline	General Laboratory	34	16.34
	Clinical Chemistry	36	17.3
	Haematology	124	59.63
	Parasitology	14	6.73

Table 1 shows that 66.3 of laboratory staff are females and the majority belong to the age group between 20- 30 years.

Table 2. Quality of laboratory services in Sawani bin Adam.

Factors affecting quality	**Yes (%)**	**No (%)**
Laboratory documentation (documents and record).	74.5	25.5
Adherence to the standard operating procedure	71.6	28.4
Customer service management.	41.8	58.2
Equipment calibration and maintenance	47.6	52.4
Laboratory quality improvement activity	49.0	51.0
External quality assessment activity	38.5	61.5
Internal quality assessment activity	62.0	38.0
Providing diagnostic service for all requested test	50.0	50.0
Providing uninterrupted laboratory service	42.3	47.7
Laboratory result verification	73.5	26.5
Laboratory results reported within turnaround time	57.7	42.3
Laboratory safety practice	64.4	35.6
Provision of quality laboratory service	51.9	48.1
Utilization of personal protective equipment.	66.3	33.7

The table 2 showed that most laboratories have a good established documentation system and staff verification, however, that quality assessment and improvement were the poorest.

Table 3. Comparison of CBC parameters among laboratories

Parameter	Mean ± SD	ANOVA F value	P value
RBC	4.75 ± 0.42	1.12	0.34
WBC	7.18 ± 1.20	0.96	0.41
Hemoglobin	13.5 ± 1.10	1.03	0.38
Platelets	265 ± 54	3.45	0.02*

*Statistically significant

Table 4. Factors associated with quality laboratory services

Factor	Good quality (%)	Poor quality (%)	P value
Staff training	62	38	0.01
Equipment maintenance	58	42	0.03
Workload	34	66	0.02
Management support	55	45	0.04

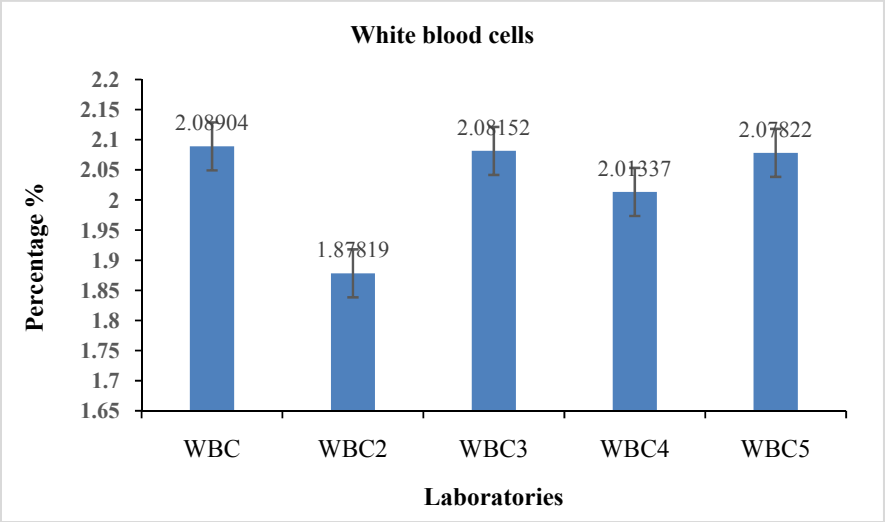

Fig 1. The white blood cells analysis

The figure 1. Illustrated that mean of WBC is similar in all laboratories with little decrease in laboratory 2.

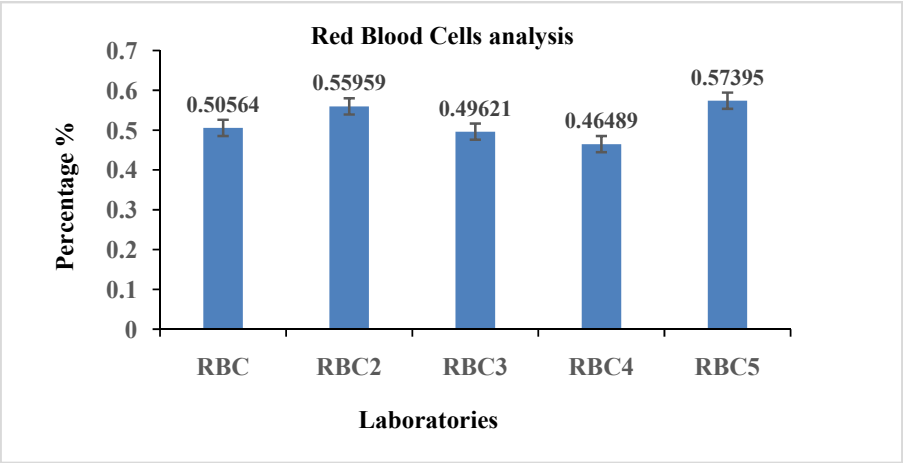

Fig 2. The Red Blood Cells analysis

Figure2. illustrated that the mean of RBC is and St deviation similar in all laboratories.

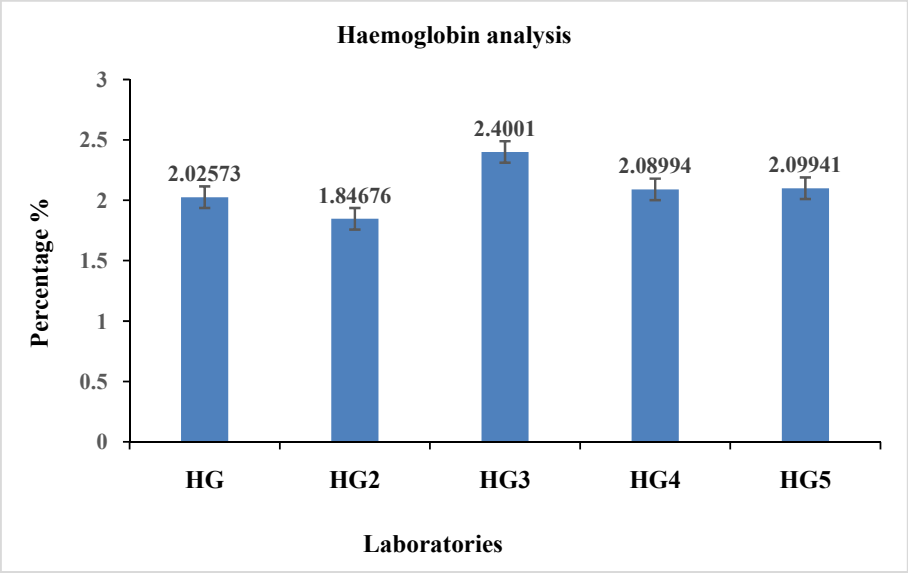

Fig 3. The Haemoglobin analysis.

F**igure** 3. Illustrated that the mean of HG and St deviation similar in most of laboratories, with difference between HG2 and HG3.

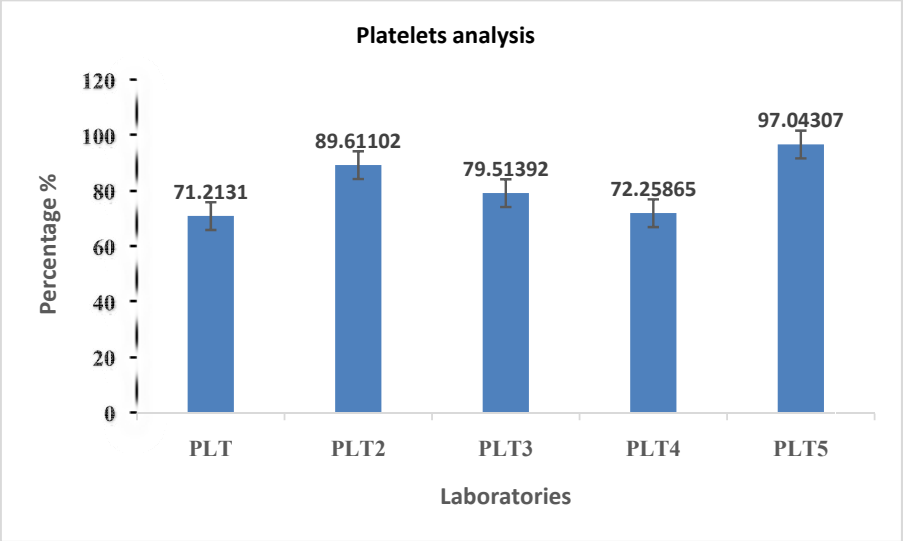

Fig 4. The Platelets analysis

Figure4.illustrated that the mean of PLT and St deviation similar in most of laboratories, with difference between laboratory PLT1 and PLT4 with PLT5 and PLT3.

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Conflict of Interest: The authors declare that there was no conflict of interest during the execution or reporting of this study.

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العوامل المؤثرة في جودة خدمات المختبرات الطبية في منطقة السواني بن ادم. طرابلس

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الملخص:
تُعدّ خدمات المختبرات الطبية ذات الجودة العالية عنصرامهما لتقديم رعاية صحية فعّالة، حيث تعتمد القرارات الطبية على دقة وموثوقية نتائج الفحوصات المخبرية. وفي العديد من الدول النامية، بما في ذلك ليبيا، لا تزال أنظمة إدارة جودة المختبرات محدودة نتيجة تحديات هيكلية وتنظيمية. هدفت هذه الدراسة إلى تقييم العوامل المؤثرة في جودة نتائج التحاليل المخبرية الطبية، وكذلك تقييم جودة خدمات المختبرات في منطقة السواني بن آدم بليبيا.أُجريت دراسة مقطعية خلال الفترة من يناير إلى يونيو 2024 شملت 22 مختبرًا طبيًا. جُمعت البيانات من 208 من العاملين بالمختبرات باستخدام استبيان صمم لتحديدالعوامل المؤثرة في جودة الخدمة. بالإضافة الي ذلك، تم تحليل 100 عينة دم مأخوذة من 20 متطوعًا أصحاء في أربع مختبرات محلية ومختبر مرجعي واحد (مختبر مستشفى أبو سليم للحوادث). أظهرت النتائج عدم وجود فروق ذات دلالة في معظم التحاليل بين المختبرات، باستثناء عدّ كريات الدم البيضاء. وبيّنت النتائج أن 80.8% من المشاركين تراوحت أعمارهم بين 20–30 سنة، وأن 63% منهم فنيونبالمختبرات، بينما يعمل 86.5% في مختبرات عامة. كما أفاد 61.5% بعدم تطبيق برامج التقييم الخارجي للجودة. وأشار ما يقارب نصف المشاركين إلى عدم كفاية جودة الخدمات، في حين أفاد 58.2% إلى غياب نظام واضح لإدارة خدمة العملاء، ويُعزى ذلك في الغالب إلى محدودية الموارد وضعف الإدارة. كما حددت الدراسة عدد من العواملالتي تؤثر في جودة خدمات المختبرات، من أهمها غياب إجراءات التشغيل القياسية، ومحدودية التطوير المهني، ونقص الإمدادات، وضعف أنظمة تقييم الجودة، وقصورإجراءات السلامة. وتوصي الدراسة بتطبيق معايير الجودة الدولية للمختبرات كجزء م السياسة الوطنية بهدف تحسين جودة أداء المختبرات في ليبيا.

الكلمات المفتاحية:عوامل الجودة، خدمات المختبرات الطبية، تحليل الدم، سواني بن ادم، ليبيا.