Rate of Peripheral Blood Smear Examination Service Provision and Its Barriers Among Public Hospitals in Southern Ethiopia: A Mixed-Methods Study

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Abstract

Introduction: Peripheral blood smear examination is a vital hematological test for diagnosis and monitoring of disorders in blood. Despite the considerable benefits of this test in the battle against the growing burden of communicable and non-communicable diseases, its rate of provision is low. This study aimed to assess the rate of peripheral blood smear examination service provision and its barriers among public hospitals in southern Ethiopia.

Method: We have conducted a descriptive cross-sectional study from January 01 to March 31, 2019, among five public hospitals in Southern Ethiopia. We collected socio-demographic data from patients and healthcare providers. We prepared peripheral blood smears from 423 patients with abnormal complete blood cell count. We examined a wright’s stained peripheral blood smear under the microscope to identify abnormality in the morphology of blood cells. We conducted key informant interviews with healthcare providers. We assessed health facilities using a standard checklist. We did descriptive statistical analysis for quantitative data using Statistical Package for Social Sciences (SPSS) version 20.0 software. We transcribed, categorized, and thematically analyzed the qualitative data. We presented the results in tables and figures.

Result: The rate of provision of peripheral blood smear examination service was 11.6% (n= 49). Nearly 90% of the eligible patients did not receive this service. Relatively better rate of service provision was seen among hospitals with essential resources for the service, and those participating in Hematology external quality assurance. Lack of training, shortage of laboratory supplies, and inadequate supportive supervision were identified as barriers to regularly provide peripheral blood smear examination service.

Conclusion: Rate of peripheral blood smear examination service provision is low. A large proportion of eligible patients missed the deserved service. Adequate laboratory supplies, training, and continued supportive supervision should be considered to improve the provision of this service.

Introduction

Laboratory test services are integral parts of the healthcare system. Peripheral blood smear examination is a laboratory test that involves microscopic analysis of blood cells on a Romanowsky stained blood smear. It helps for screening, diagnosis, and monitoring of blood disorders by providing qualitative and quantitative information [1–3]. Peripheral blood smear examination service needs a continued supply of reagent and competent healthcare workers. Quality assured medical laboratory tests, such as peripheral blood smear (PBS) examination, are the cornerstone for evidence-based decision-making on communicable and/or non-communicable diseases in modern healthcare [2, 4].

The PBS examination, a multifunctional test, plays a critical role in addressing health problems, particularly hematological disorders. Its role in providing both supportive and unique information to the complete blood cell count (CBC) rendered PBS examination irreplaceable by the contemporary automated Hematology analyzers [5–8]. In the investigation of anemia, PBS examination revealed additional
information among 11.4% and 13.9% of cases in India and Israel, respectively [7, 8]. Besides, 69.5% of PBS examination provided further information to CBC and indicated an error in automation in Malawi [9]. According to a multi-centered study in the USA, PBS examination showed sensitivity in 96% and 82% of sickle cell and myelodysplastic cases, respectively [10, 11]. Hence, this test yields maximum information for minimum cost, and sustained to support the healthcare system both in the developing and the developed world [6–9].

Despite its enormous benefits, the rate of provision of PBS examination service is low. The rate of manual PBS examination in the USA and Thailand was found to be 16.2% and 22.4%, respectively [12, 13]. PBS examination was done for only 39.2% of the eligible specimens in a public hospital of Malawi [9]. Besides, the population in the developing world has limited access to automation in Hematology that makes it difficult to deal with hematological problems in the area. Weak laboratory services hamper disease control in Africa, this poor population, at least, should not be denied to manual PBS examination service [14–16]. Laboratory services provision and quality are inadequate in Ethiopia, while the country is striving to ensure universal access to health [17, 18]. This implies the remaining gaps to alleviate the public health burden by strengthening the laboratory services that are feasible and affordable with high yield information [14].

Lack of strengthened PBS examination service results in delayed patient outcomes. Neglecting PBS examination, according to a study in India, has led to misclassification of anemia [7]. This detrimental impact can be intensified by the high prevalence of malaria coinciding with the burden of glucose-6-phosphate dehydrogenase deficiency in malaria-endemic areas [19, 20]. It also declines patient confidence in the healthcare service. This is horrible to the 21st-century healthcare system, which is vowing to ensure the delivery of quality healthcare to the world [15–21].

Continued provision of laboratory service, including PBS examination, is dependent upon quality management system, infrastructure, essential supplies, opportunity for training, and quality assurance program [3, 21, 22]. In a study conducted in Ethiopia and Tanzania, the laboratory services have been affected by poor human resource management, poor resource provision, poor management commitment, ineffective communication system, cost of laboratory commodity, low testing throughput, and lack of functional quality management system [3, 21]. Furthermore, EQA participation in India [22], staff confidence in Malawi [9], and staff training in the USA [23] impacted the laboratory service, including the rate of PBS examination service provision.

Improving the healthcare system demands quality-assured laboratory service, which is limited in the country. Moreover, strengthening laboratory services demands accurate and current information [17, 18]. Understanding laboratory service provision and the possible barriers play a crucial role in optimizing the healthcare service in the respective community. Hence, this alarms us to assess the rate of PBS examination service provision and its barriers in the study area, which lacks specific data despite the heavy burden of malaria and anemia in the area together with limited laboratory infrastructure [21, 24].
Method And Materials

Study Setting and Population

We have conducted a facility-based cross-sectional study from January 01 to March 31, 2019. We employed mixed-method research involving a sequential explanatory study design. We have included five public hospitals found in four zones (Gamo zone, Gofa zone, Konso zone, and South Omo zone) of the Southern Nations, Nationalities, and Peoples’ Region. These zones have 10 public hospitals serving about three million population in the area. Based on the availability of the PBS examination service, we have purposively selected five hospitals, namely Arba Minch General Hospital, Chencha District Hospital, Jinka General Hospital, Karat District Hospital, and Sawla General Hospital [25].

The source population was all clients meeting CBC criteria for PBS examination in public hospitals of the selected zones. The study population was all randomly selected and consented clients, who came to the public hospitals during the study period. The required sample size was determined by using a single population proportion formula at a confidence level of 95% and 5% margin of error. After considering the 50% rate of PBS examination service provision and 10% non-response rate our total sample size became 423. This sample size was uniformly distributed to health facilities. Selected patients were interviewed by systematic random sampling technique until the required sample size was reached for each hospital. The hospitals were assessed using a standard checklist for essential laboratory tests. For the qualitative component of the study, medical directors, laboratory heads, and one medical doctor were interviewed from each hospital [26, 27].

Measurement and Data Collection

Trained data collectors gathered data on patients, health professionals, and health facility-related factors by using pre-tested, structured interviewer-administered questionnaires and standard checklists. A hematologist examined Wright's stained PBS following standard operating procedure [1].

A trained professional conducted an in-depth interview for medical directors, laboratory heads, and medical doctors.

Data Quality Assurance

To ensure the quality of data, a pre-test was done on 5% of the sample size. Data collectors were trained before the commencement of the study. The questionnaire was translated into local languages. Quality control was done for laboratory reagents and all laboratory activities were done following standard operating procedures. Laboratory reagents, quality control materials, and instruments were used strictly following the manufacturer's instructions. Supervisors followed the data collection activity daily. Data were entered into EpiData V3.1 and checked for consistency.

Data Processing and Analysis
Data were coded, cleaned, and entered into EpiData version 3.1, and then checked for completeness and consistency. Then the data were exported to SPSS version 20 (SPSS Inc. Chicago, IL, USA) for analysis. Descriptive analyzes such as frequency and mean were done to summarize the data. Frequency distributions and percentages of the result were shown using tables and charts. For qualitative analysis, the recorded data were transcribed and coded. The coded data were grouped to identify themes that were related to the factors deemed to influence PBS service provision. The themes were aggregated and thematically analyzed.

**Operational Definitions**

**Abnormal CBC result**

An increased or decreased and/or flagged CBC result based on ISLH.

**Blood cell morphological abnormality**

Any morphological defect in any of the blood cell types based on ISLH.

**Awareness about hematological disorders**

A client who has ever heard about any of the common blood disorders.

**Result**

**Health Facilities**

Five public hospitals were involved in this study. Three (60%) of them are general hospitals, whereas the rest are District hospitals. The average number of clinicians and medical laboratory professionals in the participated hospitals is 128 (SD = 52.1) and 20 (SD = 8.5), respectively. The minimum and a maximum number of clinical workers are 80 and 200, respectively. Whereas, the minimum and a maximum number of medical laboratory professionals are 15 and 35, respectively. The average number of laboratory test types provided in the hospitals per year is 23.8 (SD = 9.7). The mean daily patient flow to the laboratory is 122 (SD = 52). Only one hospital provides PBS examination service more than once a day. More than half of the participated hospitals have the essential supplies to provide the PBS examination service. All of the hospitals have a functional microscope. *(Table 1)*
Table 1
Background Characteristics of public hospitals in Southern Ethiopia, 2019.

| Characteristics                                           | Category    | Frequency (%) |
|-----------------------------------------------------------|-------------|---------------|
| Hierarchy in the healthcare system                        | District    | 2(40.0)       |
|                                                            | General     | 3(60.0)       |
| Number of clinicians                                      | ≤ 130       | 3(60.0)       |
|                                                            | > 130       | 2(40.0)       |
| Number of lab personnel                                   | ≤ 20        | 4(80.0)       |
|                                                            | > 20        | 1(20.0)       |
| PBS Exam Price                                            | ≤ 15 ETB    | 4(80.0)       |
|                                                            | > 15 ETB    | 1(20.0)       |
| Number of lab test types per year                         | ≤ 20        | 3(60.0)       |
|                                                            | > 20        | 2(40.0)       |
| Number of lab clients per day                             | ≤ 120       | 3(60.0)       |
|                                                            | > 120       | 2(40.0)       |
| SLMTA and/or SLIPTA participation                          | Yes         | 4(80.0)       |
|                                                            | No          | 1(20.0)       |
| Hematology EQA participation                               | Yes         | 1(20.0)       |
|                                                            | No          | 4(80.0)       |
| Frequency of PBS Exam request in the facility              | ≥ Once a day| 1(20.0)       |
|                                                            | < Once a day| 4(80.0)       |
| Availability of PBS SOP                                    | Yes         | 1(20.0)       |
|                                                            | No          | 4(80.0)       |
| Job aid for PBS Exam Posted                                | Yes         | 3(60.0)       |
|                                                            | No          | 2(40.0)       |
| PBS included in the test menu                              | Yes         | 2(40.0)       |
|                                                            | No          | 3(60.0)       |
| Lab Handbook                                              | Yes         | 3(60.0)       |
|                                                            | No          | 2(40.0)       |
| Lancet                                                    | Yes         | 5(100.0)      |
| Characteristics                                      | Category | Frequency (%) |
|-----------------------------------------------------|----------|---------------|
| Syringe and/or needle                               | Yes      | 5(100.0)      |
|                                                     | No       | 0(0.0)        |
| EDTA tube                                           | Yes      | 3(60.0)       |
|                                                     | No       | 2(40.0)       |
| Frosted slide                                       | Yes      | 3(60.0)       |
|                                                     | No       | 2(40.0)       |
| Distill water                                       | Yes      | 3(60.0)       |
|                                                     | No       | 2(40.0)       |
| Wright stain                                        | Yes      | 2(40.0)       |
|                                                     | No       | 3(60.0)       |
| Functional microscope                               | Yes      | 5(100.0)      |
|                                                     | No       | 0(0.0)        |
| Oil immersion                                       | Yes      | 4(80.0)       |
|                                                     | No       | 1(20.0)       |
| Manual Differential counter                         | Yes      | 2(40.0)       |
|                                                     | No       | 3(60.0)       |
| Functional                                          | Yes      | 3(60.0)       |
|                                                     | No       | 2(40.0)       |
| Automated CBC Analyzer Interruption for ≥ a week    | Yes      | 4(80.0)       |
|                                                     | No       | 1(20.0)       |

**Health Professionals**

Fifty-six health professionals have participated in the quantitative part of this study. Twenty-seven (48.2%) and 29 (51.8%) of them were clinical workers, and medical laboratory workers, respectively. There is no Hematologist involved in this study from both sides.

The mean age of the participated clinicians was 33.4 years (SD = 7.4) and the majority are men. All of the clinicians were medical doctors from which 17 (63.0%) were general practitioners. No Pathologist or Hematologist participated in this study. Mean service year and monthly income of clinicians were four
years and 9,988.9 ETB, respectively. Only two (7.4%) of the clinicians were trained in PBS examination service. Also, six (22.2%) of the clinicians have requested PBS examination service more than once a day.

The mean age of the participated medical laboratory professionals was 31.2 years (SD = 6.5). The majority of them were male (55.2%) and diploma (75.9%) holders. The mean service year and monthly income of medical laboratory professionals in five years and 4,068.8 ETB, respectively. More than a third of them have attained training on both LQMS and laboratory diagnosis of malaria. However, only one (3.4%) has taken PBS training. Twenty-six (89.7%) of medical laboratory professionals have good knowledge of PBS examination, nevertheless only two (6.8%) of them do the test more than once a day. (Table 2)
### Table 2
Background characteristics of health professionals in public hospitals in Southern Ethiopia, 2019

| Characteristics                              | Category                  | Frequency (%) |
|----------------------------------------------|----------------------------|---------------|
| **Clinical Work Professionals**              |                            |               |
| Gender                                       | Male                       | 20(74.1)      |
|                                              | Female                     | 7(25.9)       |
| Age                                          | ≤ 33 years                 | 3(11.1)       |
|                                              | > 33 years                 | 24(88.9)      |
| Academic qualification                       | General Practitioner       | 17(63.0)      |
|                                              | Specialist                 | 10(37.0)      |
| Experience                                   | ≤ 24 months                | 4(14.8)       |
|                                              | > 24 months                | 23(85.2)      |
| Salary                                       | ≤ 10,000 ETB               | 17(63)        |
|                                              | > 10,000 ETB               | 10(37)        |
| PBS training                                 | Yes                        | 2(7.4)        |
|                                              | No                         | 25(92.6)      |
| PBS knowledge                                | Good                       | 23(85.2)      |
|                                              | Poor                       | 4(14.8)       |
| Frequency of requesting PBS Exam             | > Once a day               | 6(22.2)       |
|                                              | ≤ Once a day               | 21(77.8)      |
| **Medical Laboratory Professionals**         |                            |               |
| Gender                                       | Male                       | 16(55.2)      |
|                                              | Female                     | 13(44.8)      |
| Age                                          | ≤ 30 years                 | 15(51.7)      |
|                                              | > 30 years                 | 14(48.3)      |
| Academic qualification                       | Diploma                    | 22(75.9)      |
|                                              | BSc                        | 7(24.1)       |
| Experience in Months                         | ≤ 24 months                | 0(0)          |
|                                              | > 24 months                | 29(100.0)     |
Patients

The mean age of the participated patients was 29.9 years (SD = 18.2), and more than half of them were male. The average income of the patients was 1888 ETB, whereas 227 (53.7%) do not have any monthly income. The 199 (47%) of them were aware of hematological disorders. However, about three fourth of them are not interested in utilizing PBS service due to perceived high cost. (Table 3)
Table 3
Background characteristics of patients in public hospitals in Southern Ethiopia, 2019.

| Characteristics                          | Category   | Frequency (%) |
|-----------------------------------------|------------|---------------|
| Gender                                  | Male       | 228(53.9)     |
|                                         | Female     | 195(46.1)     |
| Age                                     | < 18 years | 108(25.5)     |
|                                         | 18–64 years| 288(68.1)     |
|                                         | > 64 years | 27(6.4)       |
| Educational status                      | Illiterate | 166(39.2)     |
|                                         | Literate   | 257(60.8)     |
| Monthly income                          | Yes        | 196(46.3)     |
|                                         | No         | 227(53.7)     |
| Awareness about blood disorders         | Yes        | 199(47.0)     |
|                                         | No         | 224(53.0)     |
| Willing to use PBS Exam, if requested   | Yes        | 305(72.1)     |
|                                         | No         | 118(27.9)     |

**Quantitative CBC Result**

The mean RBC, WBC and platelet count was $3.4 \times 10^6/\mu L$ (SD = 1.9), $16.4 \times 10^3/\mu L$ (SD = 26.1) and $285.1 \times 10^3/\mu L$ (SD = 264.1), respectively. RBC count and/or hemoglobin concentration was determined for all patients, but platelet and WBC count was done for 246 (58%) patients only. (Table 4)
## Table 4
Quantitative CBC result of patients among public hospitals in Southern Ethiopia, 2019.

| Characteristics   | Category | Frequency (%) |
|-------------------|----------|---------------|
| RBCs Count        | Decreased| 315 (74.5)    |
|                   | Normal   | 76 (18.0)     |
|                   | Increased| 32 (7.6)      |
| WBCs Count        | Decreased| 62 (25.3)     |
|                   | Normal   | 78 (31.7)     |
|                   | Increased| 106 (43.0)    |
| Platelets Count   | Decreased| 95 (38.6)     |
|                   | Normal   | 84 (34.2)     |
|                   | Increased| 67 (27.2)     |

### PBS Examination Service Provision

Only 49 (11.6%) of the total eligible patients were provided with PBS examination service. From 3495, 1980 have met the ISLH consensus criteria for PBS examination making the rate of PBS examination 56.7%. (Fig. 1).

Rate of PBS examination service provision among general hospitals and district hospitals was 14.9% and 6.5%, respectively. Above 20%, service provision was observed among hospitals with essential resources for PBS examination, functional CBC machine, and those participating in Hematology EQA. (Fig. 2).

### Pattern of PBS Service Provision by Hospital Characteristics

From the overall rate of PBS Examination, 49 (11.6%), 38 (77.6%) were provided by general hospitals. A higher proportion of service provision was observed among hospitals with a larger number of staff, those participating in Hematology EQA, and those with full supply for the service. (Fig. 3)

### Distribution of PBS Examination Service Provision by Patient Characteristics

The rate of PBS examination service provision was slightly higher among females (12.3%), illiterate (13.2%), aware of hematological disorder (12.2%), and those with monthly income (17.3%) compared to their respective counterparts. (Fig. 4)

### Added Value of PBS Examination Service
Examination of PBS delivered a unique finding to CBC result among 50 (23%) of the participated patients. The potentially added clinical value of the service was, 25%, 19%, and 13% for abnormalities in RBCs, WBCs and platelets, respectively. (Table 5)

| Type of blood cell | Unique Information | Percent (%) | Total |
|--------------------|--------------------|-------------|-------|
| RBC                | 58                 | 30.2        | 192   |
| WBC                | 70                 | 48.6        | 144   |
| Platelet           | 13                 | 22.4        | 58    |

Table 5
Added clinical value of PBS Examination Service in patients among public hospitals in Southern Ethiopia, 2019.

Result from Qualitative Method of the Study

We have interviewed the medical director, laboratory head, and one medical doctor from each hospital to identify the possible barriers to PBS examination service utilization. A total of fifteen health professionals were included in the interview.

Medical Directors

Half of the interviewed medical directors of the hospitals stated PBS service is good in their hospitals. “I am happy with my clinicians as well as my laboratory personnel. We try to provide high-quality service to our clients. The same is true for peripheral morphology examination.” (Participant # 4). Only one of the medical directors is confident that his hospital has the full capacity to continuously provide PBS examination service. “We have established a good system here; thanks to the SLIPTA project. We have access to good quality reagents.” (Participant # 7). The rest of the interviewed medical directors reported some obstacles to providing PBS examination service in full capacity. “We have a lot of clinicians and laboratory staff looking for training on this specific service. There is no sustainable supply of reagents as well.” (Participant # 1).

Half of the interviewed medical directors of the hospitals reported the presence of competent clinicians and laboratory professionals to provide quality assured PBS service. “As mentioned earlier, we always try to provide good service. We do have few specialist clinicians and senior laboratory technicians. In addition to this, the clinicians are working in cooperation with laboratory staff in examining the smear. Therefore, you can imagine this increases the competency.” (Participant # 4).

Lack of training and shortage of supplies were reported as the key challenges for PBS examination service in our study area. “There is no trained laboratory professional in our laboratory. There is no supportive supervision. We do not have reference books and internet access that can improve the knowledge, which is vital for the service provision. Supplies provision interrupted repeatedly” (Participant # 10).
Medical Doctors

All of the interviewed medical doctors described their view of PBS examination service as good. They expressed it as a clinically significance test. “Personally I feel PBS morphology analysis is vital laboratory service to help my patient. I strongly believe in its relevance; that is why I commonly order whenever I feel it is necessary for my patient.” (Participant # 11). Another doctor stated that “It is a very good test – it can clarify some confusing CBC results. It helps me a lot to wisely suggest the type of leukemia and anemia. It is cheap compared to the information it yields.” (Participant # 8)

Three (75%) of the interviewed medical doctors claimed that the majority of their colleagues have a good interest in using PBS examination service. “Almost all of my colleague doctors are willing to order PBS morphology analysis for their patient if the service continuously available in the laboratory.” (Participant # 5)

Lack of training was described as the principal challenge for PBS examination service. “There is no trained clinician on PBS morphology analysis in our facility. He continued and mentioned the problem among laboratory professionals as well “I doubt for the presence of any laboratory technician who took specific training on the test except in their course back in the college”. (Participant # 2)

Laboratory Heads

Half of the laboratory heads responded that the condition of the PBS service supply was good. “We have continued supply of reagents and other consumables required for PBS examination. We are providing PBS morphology examination to our clients continuously. As we are participating in the SLIPTA project we have to provide maximum quality service in general. So we have included the PBS morphology examination in our test menu, prepared SOP and determined its cost as well. We use quality assured reagents for the test. Thus, I can say it well here in our hospital.” (Participant # 9).

On the other hand, poor accessibility of laboratory supplies for PBS service is reported by half of the laboratory heads involved in the in-depth interview. “We have difficulty continuously providing PBS tests due to interruption of reagents supply. Sometimes poor quality reagents can be bought, so you have to stop the service also.” (Participant # 3).

Only one of the interviewed laboratory heads spoken they do have competent laboratory staff to provide the PBS service. “I am confident in my staff: in terms of knowledge and skill; they are capable. ... Yes... We continuously participate in Hematology EQA; for your surprise we never scored below 75%. The clinicians are happy to request the test and they also trust us.” (Participant # 9).

Three (75%) of the interviewed laboratory heads are either not confident in some of their staff competency to provide trustworthy PBS examination service. “I am confident in only two of my senior staff: they have previous exposure to work with a Pathologist, who was doing research on anemia. ( Participant # 3). Another participant reported inconsistency of staining procedure and result reporting
among his staff. “Some use shorter staining time when doing staining. Some report only RBC parameters when doing PBS analysis.” (Participant # 12).

Lack of training and shortage of supplies were identified as the main challenges for PBS examination service. “There is no trained laboratory professional in our laboratory: both technologists and technicians.” (Participant # 12). The absence of a regular supply of good quality laboratory reagents is raised as another bottleneck. “We have discarded many bottles of Wright’s stain in the last two years. It is difficult to identify white blood cells; some give you a consistently dark background even if you change staining time. Staff are not confident to generate reports by using these reagents.” (Participant # 3).

Discussion

The rate of PBS examination service in our study area was 11.6%. A significant proportion of eligible patients were not provided with PBS examination service that might have improved the clinical decision on their underlying problem. The rate of service provision is very low considering the higher number of eligible patients in the area. This finding is lower than the rate from similar studies done in the USA (27%) [28], Thailand (24.22%) [12], and Malawi (26.9%) [9]. The observed variation might have come due to the larger sample size, the socio-economic difference of our study site from these countries. While striving for universal access to health, the provision of this essential hematological test has received little attention. This reflects for the substantial gap to meet this goal in the absence of strong and sustainable laboratory service. Neglecting PBS examination renders to miss the potential added clinical value critical in the management of the patient [9, 16]. Most importantly, as depicted by Tadeu et al., lack of a laboratory service poses an extra burden by an increased probability of costly referrals, delays, and even deaths [24].

The hospital’s size, position in the healthcare hierarchy, and involvement in the quality management system affect the quantity and quality of service it provides. Likewise, the higher rate of PBS examination service provision was seen among hospitals those engaged in the SLMTA/SLIPTA project and those with a larger number of clinical staff compared to their respective counterparts. A similar pattern has been witnessed by the report from the USA [28], Senegal [29], and Addis Ababa [30], where the rate of manual blood smear scan rate elevated with an increased number of hospital beds and strengthened LQMS.

More than 20% of the patients, who visited Hematology EQA participating hospitals, have got the PBS service, compared to 5% service provision among non-participating hospitals. A similar finding was reported from India, where an external Hematology proficiency testing program has improved the quality of service provision [22]. This might be due to a lack of commitment among staff and the management together with poor supportive supervision. The majority of the interviewee reported inadequate supportive supervision. The overall management system of the hospital affects the coverage and quality of laboratory services in the hospital. This was witnessed in the study conducted by Mesfin et al, in which poor human resource management, ineffective communication system, and lack of well-established quality management system hindered the quality of laboratory services [21].
Experience and training of staff strengthen the laboratory service in the facility. Our study showed a higher proportion of the service being provided among laboratory staff those attained in-service training. Our finding is in line with the findings of studies done in different parts of Africa [15, 30]. Besides, evidence from a systematic review on studies in the USA indicated the positive influence of physicians’ experience, knowledge, and financial incentives on laboratory test utilization. In the era of strengthening evidence-based medicine the healthcare workers characteristics were affecting the pattern of laboratory service provision [23]. It is imperative to consider these variables for improving the rate of laboratory test ordering. Similarly, the interviewed medical directors in the current study stressed the vital role of training to improve service provision.

Training improves the availability and quality of healthcare. It enhances the competency and attitude of the professionals. A computer-assisted tutor on PBS in the USA helped students interpret the findings as indicated by a raised mean score of the exam from 61% in the pre-test to 91% in the post-test among students [31]. The majority of clinicians in the current study reflected a positive attitude towards PBS examination service. Even if they were convinced of its clinical significance and efficiency, they demanded training to further deepen their attitude. Lack of training on PBS service for clinicians was indicated as the challenge for sustainably providing the service. Our finding is in agreement with a study among final year medical students at Oxford University in 2010, where lack of training on Hematology shrank their attitude towards the test; which in turn reduced the service provision [23, 32]. According to the result of the study among many hospitals in the USA, clinicians gained additional information from manual PBS scan; hence, enhanced positive attitude for the service [12, 33].

Uninterrupted provision of PBS examination service demands competent laboratory personnel. In the mirror of such staff-related challenges, Hematology training provided for the healthcare workers in Tanzania improved the quality and quantity of staff [30, 34]. Likewise, the majority of the interviewed laboratory heads were not confident in their staff competency to provide quality assured PBS examination service. The concordant result was reported from Malawi, where reduced staff confidence and enthusiasm were suggested as the most important barriers to routinely provide PBS examination service in Malawi [9].

The continual availability of good quality reagents is pivotal to sustainably provide the PBS service. Lack of these resources was identified as the main challenges for PBS service in our study area. Likewise, poor provision of laboratory resources limited the quality of laboratory services in the health facilities found in Addis Ababa, Ethiopia [3, 21].

The rate of PBS examination service provision was slightly higher among patients with awareness on hematological disorder (12.2%), and those with monthly income (17.3%) compared to their respective counterparts. This could be emanated from the notion better awareness on health matter and affordability of the service strengthens the health seeking behavior and service utilization. Comparable findings were reported by Handiso et al. from Ethiopia and Sarr et al. from Senegal [29, 35].
Generally, a low rate of PBS examination service provision was observed in the study area. Lack of training, shortage of laboratory supplies, and inadequate supportive supervision were identified as barriers to the provision of PBS examination service in the study area.

**Strength of the Study**

To the best of our search for similar pieces of literature, this topic is less studied in our country. Besides, we have supported our quantitative findings with qualitative data.

**Limitations of the Study**

The scarcity of similar studies limited us to sufficiently discuss our findings. Lack of incorporation of focus group discussion in the qualitative data. Moreover, we have used the international guideline to determine the morphological abnormality of blood cells due to a lack of national guidelines.

**Conclusion And Recommendation**

The PBS examination service provision is low in the current study area. This implies negligence to the role of this cost-effective and valuable test. It shows a laboratory service, which is an integral part of healthcare, is weak in contrary to the goal of universal health coverage. Lack of training, shortage of laboratory supplies, and inadequate supportive supervision were the identified barriers to consistently provide the PBS examination service in our study setting.

We strongly recommend the hospitals initiate and strengthen the PBS service provision through availing policy manuals and other supplies. Besides, laboratory professionals should take initiative to avail of this vital test even if there is an automated hematology analyzer. Different stakeholders together with the hospital should work to facilitate training opportunities for PBS service. We strongly recommend the development of a national guideline for the PBS examination service. The authors also recommend that Ethiopia should make such a low cost-high yield laboratory test accessible at a different level of the hierarchy to facilitate achieving universal access to health goals.

**Abbreviations**

CBC
Count Blood Count
EQA
External Quality Assurance
LQMS
Laboratory Quality Management System
PBS
Peripheral Blood Smear
RBC
Declarations

Acknowledgment

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Author's Contributions

AA, ZH, TY, and TS have conceived and designed this study. AA has participated in the acquisition of data and preparation of the draft manuscript. ZH, TY, and TS were involved in drafting and critically reviewing the draft manuscript. All authors have read and approved the final manuscript.

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Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

Ethical clearance was obtained from Arba Minch University College of Medicine and Health Sciences Ethical Review Committee, and a support letter was obtained from Arba Minch University and the respective Zonal Health departments. Permission to conduct the study in public health facilities was secured from their corresponding administrators. Informed consent and/or assent from each study participant and parents, respectively, were obtained after explaining the aim of the study along with their right to refuse. The participants' information, recorded sound files, and names were anonymized. All methods were performed in accordance with approved relevant guidelines.
Consent for Publication

Not applicable.

Competing Interests

The authors declared that they have no competing interest in this research.

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Figures

**PBS Examination Service Provision**

374 (88.4%)

49 (11.6%)

**Key**

- Provided
- Not provided

**Figure 1**

Rate of PBS examination service provision among public hospitals in Southern Ethiopia, 2019.
Figure 2

Rate of PBS examination service provision by characteristics of public hospitals in Southern Ethiopia, 2019 (n= 423).
Figure 3

Pattern of PBS examination service provision among public hospitals in Southern Ethiopia, 2019 (n= 49).

Figure 4

Distribution of PBS Examination Service Provision by Patients Characteristics

Key
- Not Provided
- Provided

Patient Characteristics

Gender | Male | Female | <18 years | 18-64 years | >65 years | Illiterate | Literate | Yes | No | Yes | No | Yes | No | Yes | No

Frequency | 203 | 171 | 96 | 254 | 230 | 230 | 175 | 199 | 270 | 104 | 162 | 212 | 23 | 14 | 24 | 35 | 24

Number of observations: 49
Distribution of PBS examination service provision by patient characteristics among public hospitals in Southern Ethiopia, 2019 (n= 423).