

Research Article

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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 blood disorders. Despite its substantial role in the management of communicable and non-communicable diseases, its utilization is low. We aimed to assess the rate of peripheral blood smear examination service provision and its barriers among public hospitals in southern Ethiopia.

Method: A cross-sectional study was conducted from January 01 to March 31, 2019, in five public hospitals of Southern Ethiopia. Socio-demographic data was collected from patients and healthcare providers. Peripheral blood smears were prepared using capillary blood collected from 423 patients with abnormal complete blood cell count. The smears were stained with Wright's stain and examined under microscope by 1000X magnification to detect and identify morphological abnormality in the blood cells. A key informant interview was done with healthcare providers. Health facilities were assessed using a standard checklist. The quantitative data were analyzed by SPSS version 20 software. The qualitative data were transcribed, categorized, and thematically analyzed. The results of descriptive analyzes are presented in tables and figures.

Result: The rate of provision of peripheral blood smear examination service was 11.6%. Nearly 90% of the eligible patients did not receive this service. Relatively better rate of service provision was observed among hospitals with essential resources for the service, and those participating in Hematology external quality assurance scheme. 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 in the area. 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 vital service.

Keywords: Peripheral Blood Smear Examination, Service Provision, Barriers, Southern Ethiopia

Introduction

Laboratory test services are integral parts of the healthcare system. Peripheral blood smear (PBS) examination is a laboratory test that involves microscopic analysis of blood cells on a Romanowsky stained blood smear [1]. 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 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 [1]. 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]. Various studies confirmed the priceless significance of this test [2,6,8]. 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, staff confidence in Malawi, and staff training in the USA impacted the laboratory service, including the rate of PBS examination service provision [9, 22, 23].

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 Design, Setting and Population

A facility-based cross-sectional study was conducted in public hospitals from January 01 to March 31, 2019. A mixed-methods research involving a sequential explanatory study design was used. The study area involved 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 PBS examination service, five hospitals were purposively selected: Arba Minch General Hospital and Chencha District Hospitals (Gamo Zone), Jinka General Hospital (South Omo Zone), Karat District Hospital (Konso Zone), and Sawla General Hospital (Gofa Zone) [25].

Sample Size Determination and Sampling Technique

The study population was 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 and eligible patients were included by simple 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 from each hospital were interviewed. The corresponding physician sending each patients to CBC test was interviewed [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 trained professional conducted an in-depth interview for medical directors, laboratory heads, and medical doctors. A 2- μ L capillary blood was collected from patients with abnormal CBC result. Then, a thin smear was prepared by Wedge method and air-dried. The smear was stained with Wright's stain followed by buffering and washing. Finally, the stained smear was examined under oil-immersion field of microscope by a hematologist to detect and identify morphological abnormality in blood cells [1].

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 laboratory equipment 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. Experienced field research supervisors and the investigators did regular supervision.

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 automated CBC result based on ISLH.

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

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)
	No	0 (0.0)
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)
Monthly salary	< 4,000 ETB	18 (62.1)
	> 4,000 ETB	11 (37.9)
PBS service training	Yes	1 (3.4)
	No	28 (96.6)
Malaria Lab diagnosis training	Yes	22 (75.9)
	No	7 (24.1)
LQMS training	Yes	21 (72.4)
	No	8 (27.6)
PBS knowledge	Good	26 (89.7)
	Poor	3 (10.3)
Frequency of performing PBS Exam	> Once a day	2 (6.8)
	< Once a day	27 (93.2)

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 to utilize PBS service due to perceived high cost Table 3.

Table 3: Background characteristics of patients among 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	19 (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 $3.4 \times 10^6/\mu\text{L}$ (SD= 1.9), $16.4 \times 10^3/\mu\text{L}$ (SD= 26.1) and $285.1 \times 10^3/\mu\text{L}$ (SD= 264.1), respectively. RBC count and/or hemoglobin concentration was de-

termined for all patients, but platelet and WBC count was done for 246 (58%) patients only. For 177 patients, the hemoglobin concentration was determined by point of care tests 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 the 3,495 patients, 1,980 have met

the ISLH consensus criteria for PBS examination making the rate of PBS examination 56.7% Figure 1.

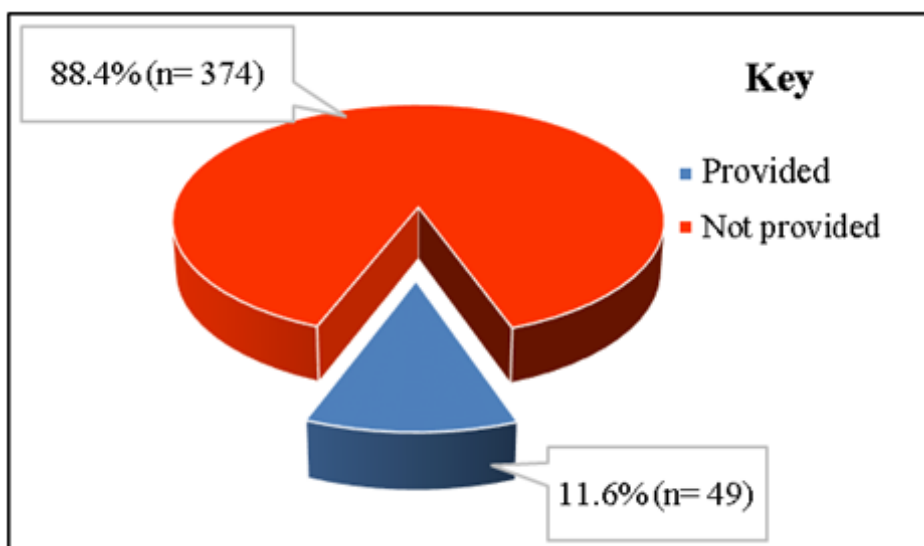


Figure 1: Rate of PBS examination service provision among public hospitals in Southern Ethiopia, 2019.

Rate of PBS examination service provision among general hospitals and district hospitals was 14.9% and 6.5%, respectively. Above 20% rate of service provision was observed among hospitals with essential resources for PBS examination, functional CBC machine, and those participating in Hematology EQA Table 5.

Table 5: Distribution of PBS examination service provision by characteristics of public hospitals in Southern Ethiopia, 2019.

Characteristics	Category	PBS Examination Service		Total
		Provided	Not Provided	
Hierarchy of the Facility	District	11 (6.5%)	157 (93.5%)	168
	General	38 (14.9%)	217 (85.1%)	255
No. of Clinicians	≤ 130	13 (5.1%)	239 (94.9%)	252
	> 130	36 (21.0%)	135 (79.0%)	171
No. of Lab personnel	≤ 20	43 (12.8%)	293 (87.2%)	336
	> 20	6 (6.9%)	81 (93.1%)	87
Client flow per day	≤ 120	41 (16.2%)	211 (83.8%)	252
	> 120	8 (4.6%)	163 (95.4%)	171
Participate in Hematology EQA	Yes	36 (21.0%)	135 (79.0%)	171
	No	13 (5.1%)	239 (94.9%)	252
Participate in SLMTA and/or SLPTA	Yes	39 (10.6%)	329 (89.4%)	368
	No	10 (18.2%)	45 (81.8%)	55
Trained Lab Personnel	Yes	19 (6.5%)	270 (93.5%)	289
	No	30 (22.4%)	104 (77.6%)	134
Experience of Clinician	≤ 24 Months	27 (22.1%)	95 (77.9%)	122
	> 24 Months	22 (7.3%)	279 (92.7%)	301
Experience of Lab Personnel	≤ 24 Months	13 (13.0%)	87 (87.0%)	100
	> 24 Months	36 (11.1%)	287 (88.9%)	323
Availability of Documents for PBS Exam	Yes	30 (26.3%)	84 (73.7%)	114
	No	19 (6.1%)	290 (93.9%)	309
CBC Machine Stopped for at least a week	Yes	42 (12.7%)	287 (87.3%)	329
	No	7 (7.5%)	87 (92.5%)	94

Currently Functional CBC Machine	Yes	36 (21.0%)	135 (79.0%)	171
	No	13 (5.1%)	239 (94.9%)	252
Currently have full supply for PBS	Yes	35 (20.4%)	136 (79.6%)	171
	No	14 (5.6%)	238 (94.4%)	252

Pattern of PBS Service Provision by Hospital Characteristics

From the 49 PBS examination services provided, 38 (77.6%) were provided by general hospitals. A higher proportion of service pro-

vision was observed among hospitals with a larger number of staff, those participating in Hematology EQA, and those with full supply for the service Figure 2.

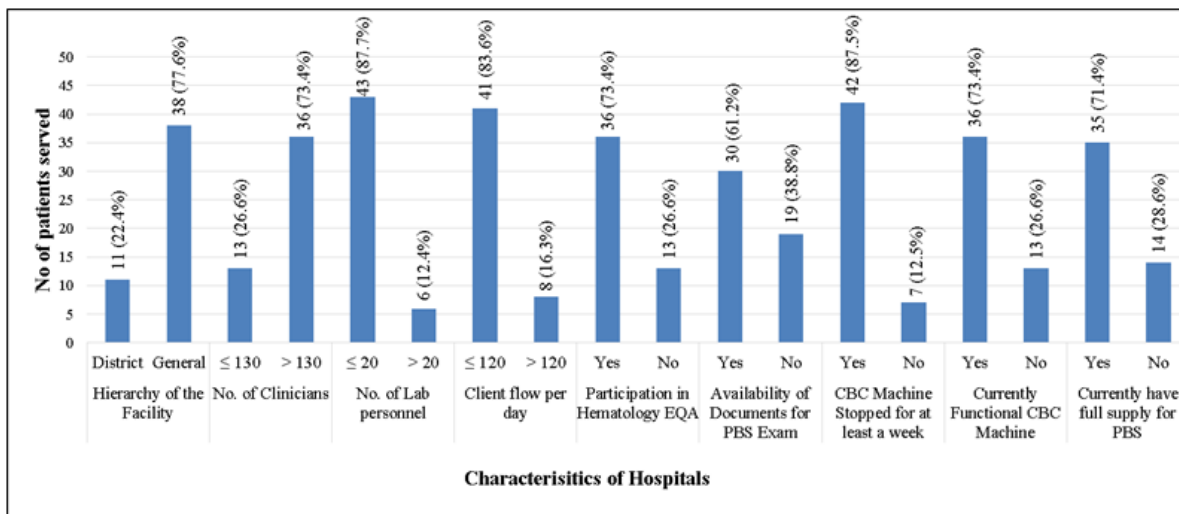


Figure 2: Distribution of PBS examination service delivered by characteristics of public hospitals in Southern Ethiopia, 2019.

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 Figure 3.

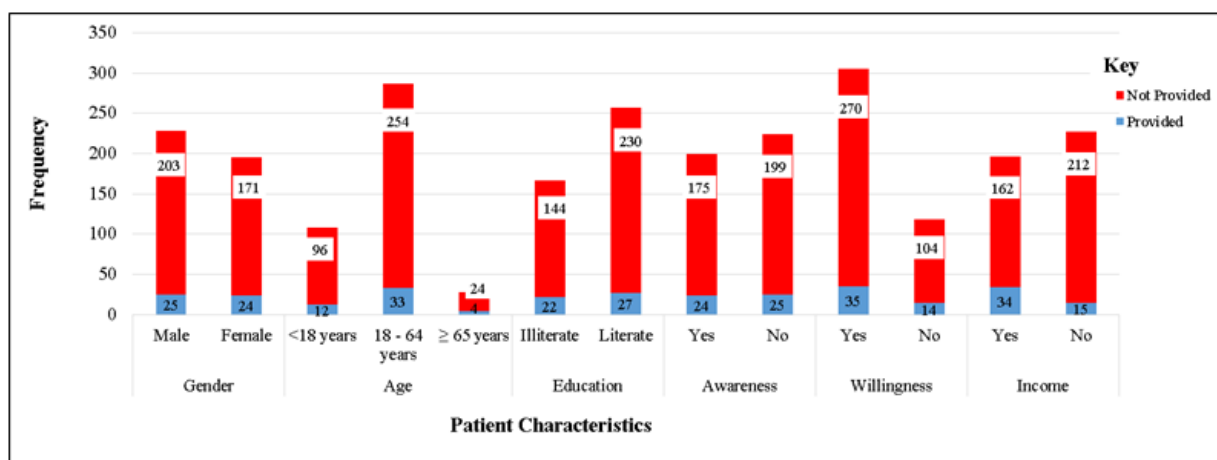


Figure 3: Distribution of PBS examination service provision by patient characteristics among public hospitals in Southern Ethiopia, 2019.

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 6.

Table 6: Added clinical value of PBS examination service in patients among public hospitals in Southern Ethiopia, 2019.

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

Result from Qualitative Method of the Study

We have interviewed medical director, laboratory head, and one medical doctor from each hospital to identify the possible barriers to PBS examination service utilization. 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, half of the laboratory heads involved in the in-depth interview report poor accessibility of laboratory supplies for PBS service. "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%), Thailand (24.22%), and Malawi (26.9%) [9, 12, 28]. The observed variation might be due to the larger sample size and 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, which is 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, 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, Senegal, and Addis Ababa, where the rate of manual blood smear scan rate elevated with an increased number of hospital beds and strengthened LQMS [28-30].

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 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 by laboratory staff, who 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]. 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, 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 examination. 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

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 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 MOH of Ethiopia should make such a low-cost-high-yield laboratory test available at various levels of the hierarchy to facilitate achieving universal access to health goals.

Abbreviations

CBC: Complete Blood Count

EQA: External Quality Assessment

ISLH: International Society for Laboratory Hematology

LQMS: Laboratory Quality Management System

PBS: Peripheral Blood Smear

RBC: Red Blood Cell

SLIPTA: Stepwise Laboratory Quality Improvement Process towards Accreditation

SLMTA: Strengthening Laboratory Management towards Accreditation

WBC: White Blood Cell

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Author's contributions

Aklilu Alemayehu, Zeleke Hailemariam, Tsegaye Yohannes, and Tamiru Shibiru have conceived and designed this study. AA has participated in the acquisition of data and preparation of the draft manuscript. Zeleke Hailemariam, Tsegaye Yohannes, and Tamiru Shibiru 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 audio files, and names were anonymized. All methods were performed in accordance with approved relevant guidelines.

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