International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 10 Issue 8 August - 2026, Pages: 1-14

Knowledge, Attitudes, and Practices of Medical Laboratory Professionals Regarding the Interpretation of Complete Blood Count Findings Associated with Non-Hematological Conditions in Gezira State, Sudan (2026)

Abeer Mohammed Fadlalla Hag Altaib [1*], Mustafa Ibrahim Abbas [2], Selma Omer Mohammed [3], Khalid Abdelsamea Mohamedahmed [4]

1 Department of Hematology and Immunohematology, Faculty of Medical Laboratory Sciences, University of Gezira, Wad Medani, Sudan, ORCID, E-mail: abeer0908223066@gmail.com

2 Department of Hematology and Immunohematology, Faculty of Medical Laboratory Sciences, University of Gezira, Wad Medani, Sudan, ORCID 0009-0000-4449-5883, E-mail: Mustibrahim93@gmail.com

3 Department of Hematology and Immunohematology, Faculty of Medical Laboratory Sciences, University of Gezira, Wad Medani, Sudan, ORCID, E-mail:

4 Department of Medical Laboratory Sciences, Faculty of Applied Medical Sciences, Jerash University, Jerash, Jordan. khalid.gu89@gmail.com. ORCID No: 0000-0001-7084-6106.

** Corresponding author: abeer0908223066@gmail.com*

Abstract: Introduction: *Accurate interpretation of complete blood count (CBC) findings in non-hematological conditions is a critical competency for medical laboratory professionals, particularly in resource-limited settings where laboratory results heavily influence clinical decisions.* ***Aim:*** *This study aimed to assess the knowledge, attitudes, and practices (KAP) of medical laboratory professionals regarding the interpretation of CBC findings associated with non-hematological clinical conditions in Gezira State, Sudan.* ***Methodology:*** *A descriptive cross-sectional study was conducted among 110 medical laboratory professionals using a structured, self-administered questionnaire covering knowledge (15 items), attitude (10 Likert items), practice (10 Likert items), and perceived barriers. Data were analyzed in SPSS version 24 using descriptive statistics, independent-samples t-test, one-way ANOVA, Chi-square tests, and Spearman correlation, with significance set at $p < 0.05$.* ***Results:*** *Knowledge was suboptimal, with 34.5% of participants classified as good, 29.1% as moderate, and 36.4% as poor; the highest-scoring item concerned the value of peripheral blood smear examination in unexplained cytopenia (88.2% correct), while the lowest concerned recognizing situations in which the reticulocyte production index is unreliable (25.5% correct). Attitudes were predominantly positive (70.0%; mean 84.1%), and practice was relatively favorable (61.8% good; mean 80.6%). Male participants scored significantly higher than females on knowledge (10.88 ± 3.31 vs. 8.91 ± 3.32; $t = 3.005$, $p = 0.003$), and knowledge level was significantly associated with gender ($\chi^2 = 9.109$, $p = 0.011$) and years of experience ($F = 3.576$, $p = 0.016$). Practice level was significantly associated with frequency of continuing professional development (CPD) participation, rising from 42.9% good practice among non-participants to 86.7% among those who participated regularly ($\chi^2 = 16.209$, $p = 0.013$). Knowledge, attitude, and practice scores were all significantly and positively correlated ($p < 0.001$).* ***Conclusion:*** *Although attitudes and practices were generally satisfactory, important knowledge gaps remain in the interpretation of CBC findings linked to non-hematological conditions. Regular CPD, targeted training on advanced interpretive skills, and standardized interpretation guidelines are recommended to strengthen diagnostic competency among medical laboratory professionals in Sudan.*

Keywords: *Complete Blood Count, Knowledge Attitudes and Practices, Non-Hematological Conditions, Medical Laboratory Professionals, Peripheral Blood Smear, Continuing Professional Development, Interpretation, Gezira State, Sudan.*

INTRODUCTION

The complete blood count (CBC), together with the erythrocyte sedimentation rate (ESR) and the peripheral blood smear (PBS), remains among the most frequently requested and clinically valuable investigations in laboratory medicine. The CBC quantifies erythrocyte, leukocyte, and platelet parameters, including hemoglobin concentration, red cell indices, and derived inflammatory ratios such as the neutrophil-to-lymphocyte ratio (NLR), while PBS offers direct morphological evaluation beyond automated analyzer output [1,2].

Hematological parameters are not confined to primary blood disorders; they are also shaped by a wide range of non-hematological conditions. Cardiovascular and metabolic disease, malignancy, and systemic inflammatory states frequently produce anemia, leukocytosis, or platelet disturbances, while organ-specific diseases such as chronic kidney disease and liver disorders generate characteristic patterns that can mimic primary hematological pathology [3,4]. In tropical settings, infectious diseases such as malaria,

typhoid, and dengue add further overlapping patterns of anemia, thrombocytopenia, and leukopenia that assist early clinical suspicion and severity assessment [5,6].

Gezira State, Sudan, is a high-burden setting for vector-borne and enteric infection because of its extensive irrigation system, making routine hematological testing central to first-line diagnosis in many facilities. Limited resources, equipment shortages, and uneven access to continuing training raise the risk that CBC abnormalities linked to non-hematological disease are misread [7,8]. Because diagnostic value depends on interpretation rather than isolated numerical output, secondary hematological changes in conditions such as sepsis and liver cirrhosis can be mistaken for primary blood disorders unless clinical context is considered [9–11].

Medical laboratory professionals sit at the centre of this diagnostic process, and the Knowledge, Attitudes, and Practices (KAP) framework is widely used in health research to evaluate their professional competence and to guide targeted training [12]. Evidence from comparable settings suggests that gaps in interpretive skill, including under-use of PBS and over-reliance on analyzer output, contribute to diagnostic error [13]. Laboratory services in Sudan, including Gezira State, continue to face workforce shortages, resource constraints, and restricted access to continuing professional development (CPD), all of which may affect interpretive competence [14,15].

Despite the diagnostic importance of CBC interpretation in non-hematological disease, there is no dedicated KAP evidence for medical laboratory professionals in Gezira State describing how hematological parameters are read alongside such conditions, leaving a clear gap in locally relevant evidence to guide training and policy. This study therefore aimed to assess the knowledge, attitudes, and practices of medical laboratory professionals regarding the interpretation of CBC findings associated with non-hematological conditions in Gezira State, Sudan, and to examine the socio-demographic and professional factors, together with the perceived barriers, associated with these KAP domains.

METHODOLOGY

A descriptive cross-sectional design was used because it is well suited to measuring knowledge, attitudes, and practices at a single point in time and to testing associations between variables without a lengthy follow-up period. The study was conducted in Gezira State, Sudan, over three months (April–July 2026), among medical laboratory professionals working in the state's public and private hospitals, laboratories, and diagnostic centres.

Participants were recruited by convenience sampling through professional networks and online platforms, and data were collected electronically via Google Forms. The sample size was calculated using the standard Cochran formula for cross-sectional studies, where $Z = 1.96$, $P = 0.5$, and $d = 0.05$, yielding a theoretical minimum sample size of 384 participants. The final analytical sample comprised 110 complete and eligible questionnaires, reflecting the accessibility of eligible participants and the response rate achieved during the study period. Eligible participants were medical laboratory professionals holding a diploma or higher qualification who were currently practicing in Gezira State and agreed to participate voluntarily; students, interns, professionals not currently practicing, and incomplete responses were excluded.

Data were collected using a structured, self-administered questionnaire developed from published KAP and hematology-interpretation literature [16–18]. The instrument comprised five sections: socio-demographic and professional characteristics; a 15-item knowledge domain assessing interpretation of CBC changes linked to non-hematological conditions, including the diagnostic role of PBS [19]; a 10-item, five-point Likert attitude domain [20]; a 10-item, five-point frequency practice domain; and a multiple-response barriers domain. The instrument was reviewed by the research supervisor and a statistician, piloted to assess clarity and content validity, and evaluated for internal consistency using Cronbach's alpha (threshold ≥ 0.70), consistent with recommended KAP validation approaches [21], before being distributed electronically.

Knowledge items were scored 1 (correct) or 0 (incorrect) for a maximum of 15 and classified as good (≥ 80%), moderate (60–79%), or poor (< 60%), following conventions used in recent KAP research [22]. Attitude and practice items were each scored on five-point Likert scales (maximum 50), with negatively worded attitude items reverse-coded, and classified as positive/good (80–100%), moderate/neutral (60–79%), or negative/poor (< 60%) [23]. Barriers were analyzed descriptively as frequencies and percentages, with multiple responses permitted.

Data were analyzed using SPSS version 24. Descriptive statistics (frequencies, percentages, means, standard deviations) summarized the sample and KAP scores. Independent-samples t-test, one-way ANOVA, Chi-square tests, and Spearman rank correlation examined associations between socio-demographic/professional variables and KAP domains, with statistical significance set at $p < 0.05$. Ethical approval was obtained from the University of Gezira Ethical Committee prior to data collection. Participation was entirely voluntary, electronic informed consent was obtained from all participants, and responses were collected and stored anonymously and confidentially, in line with standard human-subjects research practice.

RESULTS

A total of 110 completed and eligible questionnaires were analyzed. Findings are organized according to socio-demographic and professional characteristics, the knowledge, attitude, and practice (KAP) domains regarding CBC interpretation in non-hematological conditions, perceived barriers, and the associations between key variables.

Table 1: Socio-Demographic and Professional Characteristics of Participants (n = 110)

Characteristic	Category	n	%
Gender	Male	41	37.3
	Female	69	62.7
Academic qualification	Diploma	3	2.7
	Bachelor's degree (BSc)	57	51.8
	Postgraduate / Higher Diploma	5	4.5
	Master's degree (MSc)	40	36.4
	PhD / Doctorate	5	4.5
Years of experience	< 2 years	21	19.1
	2–5 years	39	35.5
	6–10 years	23	20.9
	> 10 years	27	24.5
Current workplace	Public (government) hospital laboratory	35	31.8
	Private hospital laboratory	21	19.1
	Private diagnostic laboratory (standalone)	20	18.2
	Other	17	15.5
	Teaching hospital / university laboratory	9	8.2
	Primary healthcare / polyclinic laboratory	8	7.3
Specialized training in hematology interpretation (last 5 years)	Formal in-service training / workshop	43	39.1
	Self-directed study only	34	30.9
	Short course or online training	21	19.1
	No training at all	12	10.9
Frequency of CPD participation	Rarely (< once/year)	41	37.3
	Occasionally (1–2 times/year)	33	30.0
	Never	21	19.1
	Regularly (≥ 3 times/year)	15	13.6

Percentages are column percentages within each characteristic and may not total exactly 100.0 due to rounding.

With respect to two further characteristics reported only at the level of the modal category, the most frequently represented age group was 25–34 years, the most common job title was Medical Laboratory Scientist / Technologist (n = 47, 42.7%), and the Hematology section was the most represented primary laboratory section (n = 31, 28.2%).

Table 2: Summary of Knowledge, Attitude, and Practice (KAP) Domain Scores (n = 110)

Domain	Max.	Mean (SD)	Mean %	Good/ Positive n (%)	Moderate/ Neutral n (%)	Poor/ Negative n (%)
Knowledge	15	9.65 (3.44)	64.3	38 (34.5)	32 (29.1)	40 (36.4)
Attitude	50	42.05 (5.42)	84.1	77 (70.0)	31 (28.2)	2 (1.8)
Practice	50	40.29 (8.04)	80.6	68 (61.8)	30 (27.3)	12 (10.9)

Good/Positive = ≥ 80% of maximum domain score; Moderate/Neutral = 60–79%; Poor/Negative = < 60%.

The attitude domain recorded the highest overall mean percentage (84.1%), followed by practice (80.6%), while knowledge recorded the lowest mean percentage (64.3%) and the smallest proportion of participants reaching the "good" classification (34.5%).

Knowledge Domain

The knowledge domain comprised fifteen items assessing participants' ability to interpret CBC results in non-hematological clinical conditions, scored 1 (correct) or 0 (incorrect) for a maximum of 15.

Table 3: Correct and Incorrect Responses for Knowledge Domain Items (n = 110)

Item	Knowledge Item (abbreviated)	Correct n (%)	Incorrect n (%)
K1	Mechanism of normocytic anemia in chronic renal failure	69 (62.7)	41 (37.3)

K2	CBC finding most characteristic of tuberculosis	65 (59.1)	45 (40.9)
K3	Condition most associated with elevated NLR	85 (77.3)	25 (22.7)
K4	CBC combination expected in decompensated liver cirrhosis	68 (61.8)	42 (38.2)
K5	Elevated RDW without anemia does not always indicate pathology (T/F)	63 (57.3)	47 (42.7)
K6	ESR value consistent with active SLE flare	68 (61.8)	42 (38.2)
K7	Thrombocytopenia in dengue does not reflect primary bone marrow failure (T/F)	75 (68.2)	35 (31.8)
K8	WBC pattern most suggestive of bacterial sepsis	87 (79.1)	23 (20.9)
K9	PBS is an essential complement to CBC in unexplained cytopenia (T/F)	97 (88.2)	13 (11.8)
K10	CBC findings expected in Plasmodium falciparum malaria	72 (65.5)	38 (34.5)
K11	Most likely cause of macrocytosis with round macrocytes and normal MCHC	54 (49.1)	56 (50.9)
K12	Situations where the reticulocyte production index (RPI) may be unreliable	28 (25.5)	82 (74.5)
K13	Most likely cause of normocytic normochromic anemia in the clinical scenario	70 (63.6)	40 (36.4)
K14	RDW of 13.5% does not suggest iron supplementation alone corrects anemia (T/F)	76 (69.1)	34 (30.9)
K15	Correct interpretation reflecting the clinical picture of dengue fever	84 (76.4)	26 (23.6)

The highest proportion of correct responses was recorded for item K9 (PBS as an essential complement to CBC in unexplained cytopenia), at 88.2% (n = 97), while the lowest was recorded for item K12 (recognizing situations where the RPI may be unreliable), at 25.5% (n = 28).

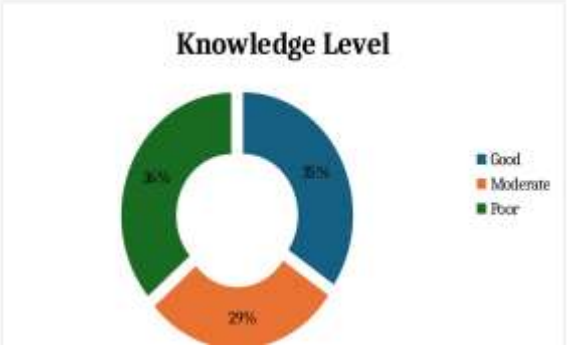

Figure 1: Overall Knowledge Level of Participants Regarding CBC Interpretation in Non-Hematological Conditions (n = 110)

Attitude Domain

Attitudes were assessed through ten items rated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Table 4: Distribution of Attitude Domain Items (n = 110)

Item	Attitude Statement (abbreviated)	SA n(%)	A n(%)	N n(%)	D n(%)	SD n(%)	Mean
A1	Clinical information is essential for accurate CBC interpretation	75(68.2)	29(26.4)	5(4.5)	1(0.9)	–	4.62
A2	Confidence in interpreting CBC in chronic systemic diseases	32(29.1)	45(40.9)	22(20.0)	8(7.3)	3(2.7)	3.86
A3	CBC abnormalities must be interpreted in overall clinical context	42(38.2)	44(40.0)	16(14.5)	5(4.5)	3(2.7)	4.06
A4	PBS provides additional diagnostic value	64(58.2)	21(19.1)	18(16.4)	4(3.6)	3(2.7)	4.26

	beyond automated CBC						
A5	Regular CPD is necessary to maintain interpretation competence	51(46.4)	34(30.9)	17(15.5)	7(6.4)	1(0.9)	4.15
A6	Correlation of CBC findings with clinical conditions is essential	55(50.0)	39(35.5)	11(10.0)	5(4.5)	–	4.31
A7	Clinician collaboration improves patient management outcomes	71(64.5)	24(21.8)	9(8.2)	4(3.6)	2(1.8)	4.44
A8	NLR is a clinically useful index for routine reporting	24(21.8)	49(44.5)	30(27.3)	7(6.4)	–	3.82
A9	Lack of correlation may lead to misleading interpretation	49(44.5)	38(34.5)	11(10.0)	10(9.1)	2(1.8)	4.11
A10	Interpretive comments add clinical value to laboratory reports	60(54.5)	40(36.4)	7(6.4)	2(1.8)	1(0.9)	4.42

SA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly Disagree. Scores are out of 5.

The highest mean score was recorded for item A1 (clinical information as essential for accurate CBC interpretation; mean = 4.62), indicating near-universal endorsement, while the lowest mean was recorded for item A8 (NLR as a useful index for routine reporting; mean = 3.82).

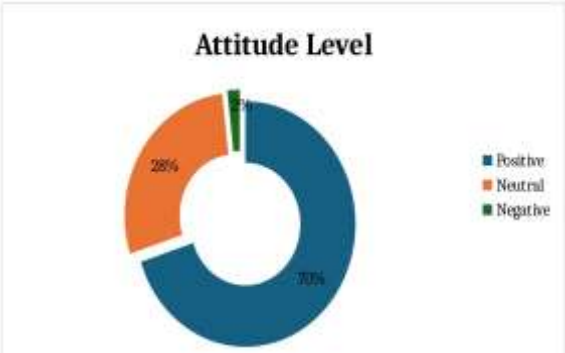

Figure 2: Overall Attitude Level of Participants Regarding CBC Interpretation in Non-Hematological Conditions (n = 110)

The overall mean attitude score was 42.05 out of 50 (84.1%), and 70.0% (n = 77) of participants demonstrated an overall positive attitude.

Practice Domain

The practice domain was assessed using ten items rated on a five-point frequency scale (1 = Never to 5 = Always).

Table 5: Distribution of Practice Domain Items (n = 110)

Item	Practice Statement (abbreviated)	Always n(%)	Often n(%)	Sometimes n(%)	Rarely n(%)	Never n(%)	Mean
P1	Review clinical information before interpreting CBC	74(67.3)	19(17.3)	10(9.1)	5(4.5)	2(1.8)	4.44
P2	Add interpretive comments when CBC suggests systemic condition	55(50.0)	24(21.8)	16(14.5)	9(8.2)	6(5.5)	4.03
P3	Perform / request PBS when CBC is abnormal or	65(59.1)	17(15.5)	18(16.4)	5(4.5)	5(4.5)	4.20

	discordant						
P4	Contact clinician to clarify ambiguous results	45(40.9)	27(24.5)	27(24.5)	8(7.3)	3(2.7)	3.94
P5	Calculate / report derived CBC indices (NLR, Mentzer Index)	28(25.5)	37(33.6)	18(16.4)	16(14.5)	11(10.0)	3.50
P6	Follow standardized protocol for critical / panic CBC values	63(57.3)	23(20.9)	14(12.7)	6(5.5)	4(3.6)	4.23
P7	Differentiate primary hematological from secondary changes in reports	44(40.0)	27(24.5)	15(13.6)	13(11.8)	11(10.0)	3.73
P8	Recognize lipemic interference and take corrective action	58(52.7)	27(24.5)	16(14.5)	6(5.5)	3(2.7)	4.19
P9	Determine if leukocytosis is primary or reactive before reporting	56(50.9)	18(16.4)	23(20.9)	6(5.5)	7(6.4)	4.00
P10	Consider medication history when interpreting unexpected CBC results	55(50.0)	24(21.8)	17(15.5)	9(8.2)	5(4.5)	4.05

The most consistently performed practice was reviewing clinical information before interpreting CBC results (P1; mean = 4.44), with 67.3% (n = 74) reporting this as always performed, while the least consistently performed was calculating or reporting derived CBC indices such as NLR and the Mentzer index (P5; mean = 3.50).

Figure 3: Overall Practice Level of Participants Regarding CBC Interpretation in Non-Hematological Conditions (n = 110)

The overall mean practice score was 40.29 out of 50 (80.6%), and 61.8% (n = 68) of participants demonstrated a good level of practice.

Barriers and Challenges to Accurate Hematological Interpretation

Participants were invited to select all barriers affecting their ability to interpret hematological results accurately. Because multiple responses were permitted, the sum of frequencies exceeds the total sample size.

Table 6: Frequency of Reported Barriers to Accurate Hematological Interpretation (Multiple Response; n = 110)

Rank	Barrier	Frequency	Respondents (%)
1	Insufficient training in hematological interpretation	67	60.9
2	Lack of clinical information on laboratory request forms	66	60.0
3	Excessive workload / high sample volume	55	50.0

4	Poor communication channels with clinical staff	49	44.5
5	Time pressure limiting detailed result review	42	38.2
5	Over-reliance on automated analyzer results without manual review	42	38.2
7	Absence of institutional interpretive reporting guidelines	41	37.3
8	Unavailability of peripheral blood smear microscopy	40	36.4
9	Insufficient CPD opportunities at the institution	37	33.6
10	Limited access to reference materials or clinical guidelines	35	31.8
–	None of the above	9	8.2

The principal barriers were insufficient training in hematological interpretation (60.9%) and lack of clinical information on request forms (60.0%), followed by excessive workload (50.0%). Only 8.2% of participants reported no barriers at all.

Associations Between Variables

One-way ANOVA was used for comparisons across three or more independent groups, independent-samples t-test for binary comparisons, Chi-square tests for categorical level classifications, and Spearman correlation for inter-domain relationships. Statistical significance was set at $p < 0.05$.

Table 7: One-Way ANOVA — Knowledge Score by Academic Qualification (n = 110)

Qualification	n	Mean	SD	F / df / p
Diploma	3	5.00	1.73	F = 2.321; df = 4,105; p = 0.061
Bachelor's degree	57	9.56	3.52	
Postgraduate / Higher Diploma	5	8.20	2.95	
Master's degree (MSc)	40	10.03	3.30	
PhD / Doctorate	5	11.80	1.79	
Total	**110**	**9.65**	**3.44**	

Mean knowledge scores increased with higher academic qualification, ranging from 5.00 among diploma holders to 11.80 among PhD holders, but this association was not statistically significant ($F = 2.321$; df = 4, 105; $p = 0.061$).

Table 8: One-Way ANOVA — Knowledge Score by Years of Professional Experience (n = 110)

Years of Experience	n	Mean	SD	F / df / p
< 2 years	21	9.48	3.50	F = 3.576; df = 3,106; p = 0.016*
2–5 years	39	8.38	3.46	
6–10 years	23	10.65	3.10	
> 10 years	27	10.74	3.23	
Total	**110**	**9.65**	**3.44**	

There was a statistically significant association between years of experience and knowledge score ($F = 3.576$; df = 3, 106; $p = 0.016$). Participants with more than 10 years of experience recorded the highest mean score (10.74), while those with 2–5 years recorded the lowest (8.38).

Table 9: Independent-Samples t-Test — Knowledge Score by Gender (n = 110)

Gender	n	Mean (/15)	SD	t / df / p
Male	41	10.88	3.31	t = 3.005; df = 108; p = 0.003*
Female	69	8.91	3.32	
Total	**110**	**9.65**	**3.44**	

Male participants recorded a significantly higher mean knowledge score (10.88 ± 3.31) than female participants (8.91 ± 3.32; $t = 3.005$; df = 108; $p = 0.003$).

Table 10: Chi-Square Analysis — Knowledge Level Classification by Gender (n = 110)

Gender	Good n (%)	Moderate n (%)	Poor n (%)	Total n (%)
Male	21 (51.2)	11 (26.8)	9 (22.0)	41 (100.0)
Female	17 (24.6)	21 (30.4)	31 (44.9)	69 (100.0)
Total	**38 (34.5)**	**32 (29.1)**	**40 (36.4)**	**110 (100.0)**

*$\chi^2 = 9.109$; df = 2; $p = 0.011$**

A significantly higher proportion of male participants (51.2%) reached a good knowledge level compared to female participants (24.6%), while a higher proportion of female participants (44.9%) were classified as poor compared to male participants (22.0%) ($\chi^2 = 9.109$; df = 2; $p = 0.011$).

Table 11: Chi-Square Analysis — Knowledge Level Classification by Years of Experience (n = 110)

Years of Experience	Good n (%)	Moderate n (%)	Poor n (%)	Total n (%)
< 2 years	6 (28.6)	7 (33.3)	8 (38.1)	21 (100.0)
2–5 years	9 (23.1)	10 (25.6)	20 (51.3)	39 (100.0)
6–10 years	11 (47.8)	7 (30.4)	5 (21.7)	23 (100.0)
> 10 years	12 (44.4)	8 (29.6)	7 (25.9)	27 (100.0)
Total	**38 (34.5)**	**32 (29.1)**	**40 (36.4)**	**110 (100.0)**

$\chi^2 = 8.514$; df = 6; p = 0.203

No statistically significant association was found between knowledge level classification and years of experience (χ^2 = 8.514; df = 6; p = 0.203), in contrast to the significant association observed for the continuous knowledge score.

Table 12: One-Way ANOVA — Attitude Score by Specialized Training Status (n = 110)

Training Status	n	Mean	SD	F / df / p
No training at all	12	42.33	6.12	F = 0.117; df = 3,106; p = 0.950
Self-directed study only	34	41.74	6.89	
Short course or online training	21	41.76	7.22	
Formal in-service training / workshop	43	42.37	6.44	
Total	**110**	**42.05**	**6.64**	

No statistically significant association was found between type of specialized training and overall attitude score (F = 0.117; df = 3, 106; p = 0.950); mean scores were remarkably similar across all categories.

Table 13: Chi-Square Analysis — Attitude Level Classification by Specialized Training Status (n = 110)

Training Status	Positive n (%)	Neutral n (%)	Negative n (%)	Total n (%)
No training at all	9 (75.0)	3 (25.0)	0 (0.0)	12 (100.0)
Self-directed study only	24 (70.6)	9 (26.5)	1 (2.9)	34 (100.0)
Short course or online training	13 (61.9)	7 (33.3)	1 (4.8)	21 (100.0)
Formal in-service training / workshop	31 (72.1)	12 (27.9)	0 (0.0)	43 (100.0)
Total	**77 (70.0)**	**31 (28.2)**	**2 (1.8)**	**110 (100.0)**

$\chi^2 = 2.782$; df = 6; p = 0.836

No statistically significant association was found between attitude level classification and specialized training status (χ^2 = 2.782; df = 6; p = 0.836).

Table 14: One-Way ANOVA — Practice Score by Frequency of CPD Participation (n = 110)

CPD Participation	n	Mean	SD	F / df / p
Never	21	36.81	8.43	F = 3.628; df = 3,106; p = 0.015*
Rarely (< once/year)	41	39.41	7.28	
Occasionally (1–2 times/year)	33	41.48	6.51	
Regularly (≥ 3 times/year)	15	44.93	5.87	
Total	**110**	**40.29**	**7.46**	

There was a statistically significant association between frequency of CPD participation and practice score (F = 3.628; df = 3, 106; p = 0.015), with a positive monotonic trend: practice scores rose progressively from 36.81 among those who never participated to 44.93 among those who participated regularly.

Table 15: One-Way ANOVA — Practice Score by Current Workplace Setting (n = 110)

Workplace Setting	n	Mean	SD	F / df / p
Primary healthcare / polyclinic laboratory	8	37.62	8.50	F = 1.023; df = 5,104; p = 0.408
Private diagnostic laboratory (standalone)	20	38.40	7.81	
Other	17	39.76	8.03	
Private hospital laboratory	21	40.52	6.95	
Public (government) hospital laboratory	35	40.94	7.02	

Teaching hospital / university laboratory	9	44.78	5.43	
Total	**110**	**40.29**	**7.46**	

No statistically significant association was found between workplace setting and practice score ($F = 1.023$; $df = 5, 104$; $p = 0.408$), although the highest mean score was observed in teaching hospital / university laboratories (44.78) and the lowest in primary healthcare settings (37.62).

Table 16: Chi-Square Analysis — Practice Level Classification by Frequency of CPD Participation (n = 110)

CPD Participation	Good n (%)	Moderate n (%)	Poor n (%)	Total n (%)
Never	9 (42.9)	6 (28.6)	6 (28.6)	21 (100.0)
Rarely (< once/year)	24 (58.5)	11 (26.8)	6 (14.6)	41 (100.0)
Occasionally (1–2 times/year)	22 (66.7)	11 (33.3)	0 (0.0)	33 (100.0)
Regularly (≥ 3 times/year)	13 (86.7)	2 (13.3)	0 (0.0)	15 (100.0)
Total	**68 (61.8)**	**30 (27.3)**	**12 (10.9)**	**110 (100.0)**

*$\chi^2 = 16.209$; $df = 6$; $p = 0.013$**

There was a statistically significant association between practice level classification and CPD participation frequency ($\chi^2 = 16.209$; $df = 6$; $p = 0.013$), with good practice rising from 42.9% among non-participants to 86.7% among regular participants.

Table 17: Spearman Rank Correlation Coefficients Between KAP Domain Scores (n = 110)

Domain	Knowledge Score	Attitude Score	Practice Score
Knowledge Score	1.000	0.608**	0.377**
Attitude Score	0.608**	1.000	0.542**
Practice Score	0.377**	0.542**	1.000

*** $p < 0.001$ (two-tailed). Spearman's rho (ρ) reported.*

All inter-domain correlations were statistically significant. The strongest correlation was observed between knowledge and attitude scores ($\rho = 0.608$), followed by attitude and practice scores ($\rho = 0.542$), while the correlation between knowledge and practice scores was weaker but remained significant ($\rho = 0.377$).

DISSCUSSION

This descriptive cross-sectional study assessed the knowledge, attitudes, practices, and perceived barriers of medical laboratory professionals regarding the interpretation of CBC findings in non-hematological conditions in Gezira State, Sudan. Participants were predominantly young, female, bachelor's-degree holders with heterogeneous professional experience, and many reported only intermittent access to specialized training and continuing professional development (CPD). This profile is important context for the KAP pattern observed and suggests that interpretation practice in this setting is shaped by workplace exposure and training access as much as by formal education.

Attitudes were markedly stronger than knowledge, with 70.0% of participants positive and a mean score of 84.1%. The most strongly endorsed statement was that clinical information is essential for accurate CBC interpretation, followed by the value of clinician collaboration and interpretive reporting comments, indicating that participants grasped the importance of contextual interpretation even where technical knowledge was imperfect. The comparatively lower endorsement of the neutrophil-to-lymphocyte ratio (NLR) as a routine reporting index suggests some caution about incorporating newer derived indices into daily practice. These findings echo Olum et al. (2021) [24] in Uganda, who reported positive attitudes toward continuing professional education and diagnostic quality improvement, and Yang et al. (2025) [25] in China, who found favorable attitudes toward laboratory learning despite knowledge gaps. The absence of a significant association between attitude and specialized training status ($p = 0.950$) or attitude classification ($p = 0.836$) suggests that positive attitudes are broadly shared across training categories, perhaps because clinical correlation is already a strongly held professional norm.

Practice was also comparatively strong, with 61.8% classified as good and a mean score of 80.6%. The most consistently applied behavior was reviewing clinical information before interpreting CBC results, followed by requesting peripheral blood smear (PBS) examination for abnormal or discordant results and following standardized protocols for critical values; the weakest area was calculating or reporting derived indices such as NLR and the Mentzer index, together with differentiating primary from secondary hematological change. This suggests that foundational interpretive habits are well established while more advanced analytical practices are not yet routine. The pattern is consistent with Binda et al. (2022) [26] in Tanzania, who linked supervision and continuing education to stronger quality-related practice, and with Ahmed et al. (2023) [15] in Gezira State, who found that continuing professional development was associated with improved laboratory practice. The significant association between practice level and CPD frequency observed in the present study ($p = 0.013$) reinforces the practical value of sustained training exposure.

The barrier profile clarifies why gaps persist alongside broadly positive attitudes and acceptable practice. The most frequently reported obstacles were insufficient training in hematological interpretation (60.9%), lack of clinical information on request forms (60.0%), and excessive workload (50.0%), followed by poor communication with clinicians and time pressure. These barriers directly undermine the behaviors participants valued most, particularly contextual interpretation and clinician collaboration, meaning that even knowledgeable staff may underperform where request forms are incomplete or workload is heavy. This is consistent with Ahmed et al. (2023) [15] in Gezira State, who identified inadequate training, guideline shortage, and workload as major constraints, and with Binda et al. (2022) [26] in Tanzania and Mbemba et al. (2026) [27] in the Republic of Congo, both of which highlighted guideline absence and limited continuing education as central barriers to laboratory interpretation quality.

Mean knowledge scores rose with academic qualification, from diploma to PhD level, but the association did not reach significance ($p = 0.061$), likely reflecting the small diploma and PhD subgroups and the possibility that formal qualification alone does not guarantee interpretive competence. Years of experience, by contrast, were significantly associated with knowledge score ($p = 0.016$), with the highest means among those with more than ten years and six-to-ten years of experience, broadly consistent with Alenazi et al. (2023) [28] in Saudi Arabia, who linked postgraduate training and recent continuing education to stronger competency.

Gender was also significantly associated with knowledge, both as a continuous score ($p = 0.003$) and as a categorical level ($p = 0.011$), with male participants scoring higher. This finding should be interpreted cautiously, as it may reflect differences in section allocation, training access, or other unmeasured institutional factors rather than inherent ability; it is broadly consistent with the gender-related differences in interpretation competency reported by Yang et al. (2025) [25] in China, although the direction and explanation may not generalize across settings. In contrast, knowledge level classification was not significantly associated with years of experience ($p = 0.203$), and practice score was not significantly associated with workplace setting ($p = 0.408$), suggesting that categorical analyses were less sensitive than continuous scores, and that institutional and workflow differences across settings were not large enough to reach significance.

Knowledge, attitude, and practice scores were all significantly and positively correlated (knowledge–attitude $\rho = 0.608$; attitude–practice $\rho = 0.542$; knowledge–practice $\rho = 0.377$; all $p < 0.001$), supporting the KAP framework's premise that stronger understanding accompanies more favorable professional beliefs and that favorable beliefs are linked to better routine practice [12]. This pattern implies that training focused on knowledge alone may be insufficient unless it also reinforces clinical reasoning, confidence, and communication.

Several limitations should temper these findings. The cross-sectional design precludes causal inference. Convenience sampling via an online platform may have favored more digitally connected or academically engaged professionals. The achieved sample of 110 was smaller than the calculated target, limiting statistical power for some subgroup comparisons. Reliance on self-report may have introduced social desirability or recall bias, meaning some favorable practices may be overestimated and some barriers underreported.

CONCLUSION

The evaluation of knowledge, attitudes, and practices among medical laboratory professionals in Gezira State revealed a moderate overall level of knowledge (64.3%) regarding CBC interpretation in non-hematological conditions, with only around a third of participants reaching a good knowledge level, despite generally positive attitudes (84.1%) and satisfactory practice (80.6%). Notable gaps remained in advanced interpretive tasks, including the calculation of derived CBC indices and the differentiation of primary from secondary hematological change, while insufficient training, incomplete clinical information on request forms, and heavy workload were identified as the principal barriers to accurate interpretation. Higher knowledge was associated with greater professional experience and, to a lesser and more cautious extent, with gender, while regular participation in continuing professional development was linked to stronger practice. Because knowledge, attitude, and practice were all significantly and positively correlated, targeted training that strengthens interpretive knowledge is likely to also reinforce professional attitudes and day-to-day practice. Structured CPD programmes, standardized request forms and interpretation guidelines, wider availability of peripheral blood smear microscopy, and stronger clinician-laboratory communication are recommended to close these gaps and support the quality of hematology diagnostic services in Sudan.

REFERENCES

[1] Seo, I.H. and Lee, Y.J., 2022. Usefulness of complete blood count (CBC) to assess cardiovascular and metabolic diseases in clinical settings: a comprehensive literature review. Biomedicines, 10(11), p.2697.

[2] Nelson, G.T., Brown, A.J. and Carter, L.M., 2024. Peripheral blood smear interpretation in the era of automated hematology analyzers: bridging the competency gap in clinical laboratories. International Journal of Laboratory Hematology, 46(2), pp.198–210.

[3] Mackenzie, R.J., Thompson, P.A. and Williams, H.K., 2022. Inflammatory biomarkers derived from routine hematological parameters: current clinical significance and diagnostic utility in non-hematological conditions. British Journal of Haematology, 198(4), pp.712–725.

[4] Hassan, E.M., Osman, B.A. and Khalid, S.E., 2021. Hematological alterations in patients with chronic renal failure at Sudanese hospitals: a comparative cross-sectional

study. African Journal of Laboratory Medicine, 10(1), pp.1–9.

[5] Boua, B.B., Ndam, N.T., Costa, D. and Machado, M., 2022. Evaluation of blood cell count parameters as predictors of treatment failure of malaria in Angola: an observational study. Access Microbiology, 4(5), p.000349.

[6] Yahaya, S., Iftikhar, M. and Malik, A., 2023. Utilization of the complete blood count in diagnosing endemic infectious diseases in Pakistan: a narrative review. Journal of the Pakistan Medical Association, 73(10), pp.2034–2041.

[7] Ibrahim, A.H., Eltahir, M.S., Suliman, M.A. and Mohammed, O.A., 2023. Epidemiological profile of major infectious diseases in Gezira State, Sudan: malaria, schistosomiasis, and enteric fever (2018–2022). Sudan Medical Monitor, 18(2), pp.78–89.

[8] Ahmed, S.A. and Hassan, M.I., 2022. Knowledge and practices of medical laboratory professionals regarding hematological test interpretation in Khartoum State, Sudan: a cross-sectional study. Sudanese Journal of Medical Sciences, 17(3), pp.112–124.

[9] Burack, W.R. and Lichtman, M.A., 2025. The complete blood count — time to assess what is impactful and what is distracting. JAMA Network Open, 8(6), e2514055.

[10] Agnello, L., Giglio, R.V., Bivona, G., Scazzone, C., Gambino, C.M., Iacona, A., Ciaccio, A.M., Lo Sasso, B. and Ciaccio, M., 2021. The value of a complete blood count (CBC) for sepsis diagnosis and prognosis. Diagnostics, 11(10), p.1881.

[11] Fierro-Angulo, O.M., González-Regueiro, J.A., Pereira-García, A., Ruiz-Margáin, A., Solis-Huerta, F. and Macías-Rodríguez, R.U., 2024. Hematological abnormalities in liver cirrhosis. World Journal of Hepatology, 16(9), pp.1229–1244.

[12] World Health Organization, 2023. Laboratory Quality Management System Handbook. Geneva: World Health Organization.

[13] Yusuf, A.M., Abubakar, I., Abdullahi, S.T. and Garba, B., 2024. Knowledge, attitudes, and practices of medical laboratory scientists regarding interpretation of non-specific hematological findings in endemic disease settings: a multicenter KAP study in northern Nigeria. BMC Health Services Research, 24(1), p.456.

[14] Nkengasong, J. and Tessema, S., 2023. Laboratory medicine and health systems strengthening in Africa. The Lancet Global Health, 11(3), pp.e301–e302.

[15] Ahmed, E.A., Alaagib, N.A., Nour, B.Y.M. and Dafalla, A.M., 2023. Personnel and safety practices in medical laboratories, Sudan: the challenges to achieving goals. International Journal of Academic Health and Medical Research, 7(10), pp.13–16.

[16] Muratoćovć, S., Hadžimuratović-Mujanović, A. and Šabanović, E., 2025. Development and validation of a work quality questionnaire in medical biochemistry laboratories: a KAP approach. Journal of Health Sciences, 15(2), p.e2887.

[17] Kamble, S., Negalur, N. and Bhat, K., 2020. Study of hematological parameters in patients with non-hematological malignancies and their correlation with disease stage. International Journal of Advanced Research, 8(6), pp.1022–1029.

[18] Ozyer, U. and Dikmen, N., 2024. Unraveling the clinical significance and prognostic value of the neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, systemic immune-inflammation index, and systemic inflammation response index: an extensive literature review. Turkish Journal of Emergency Medicine, 24(1), pp.14–24.

[19] Goswami, B., Singh, B., Chawla, R. and Mallika, V., 2014. Utility of peripheral blood smear findings and its correlation with automated hematology analyzer. Journal of Laboratory Physicians, 6(2), pp.109–113.

[20] Gwak, M.S., Yang, Y., Kim, G.S., Lee, S.H., Park, J.H., Choi, Y.J., Kim, H.J., Jung, S.Y., Lim, Y.S. and Kim, J.T., 2025. Healthcare professionals' knowledge, attitudes, and practices in using thromboelastography in perioperative coagulation management. BMC Health Services Research, 25(1), pp.1–12.

[21] Alomari, A., Alshammari, M., Al-Amri, A., Alqahtani, S., Alzahrani, N., Alharbi, A. and Almutairi, R., 2025. Development, validation, and reliability of a knowledge, attitudes, and practices questionnaire on bloodborne pathogens among healthcare workers. American Journal of Biomedical Science and Research, 28(1), pp.1–10.

[22] Delie, A., Tesfaye, B., Getachew, M. and Alemu, S., 2024. Knowledge, attitude, and practice towards clinical laboratory utilization among healthcare professionals: a cross-sectional study. BMC Public Health, 24, Article 19811.

[23] Wang, L., Zhang, Y., Li, X. and Chen, H., 2022. Knowledge, attitudes, and practices (KAP) towards health-related issues: a cross-sectional study. Frontiers in Public Health, 10, Article 880774.

[24] Olum, R., Bongomin, F. and colleagues, 2021. Knowledge, attitudes and practices toward evidence-based medicine among healthcare professionals. BMC Medical Education, 21, p.609.

[25] Yang, X., Liu, Y. and colleagues, 2025. Development and validation of the Clinical Laboratory Knowledge and Attitudes Questionnaire among medical interns. Frontiers in Medicine, 12, p.1726666.

[26] Binda, F., Mboya, I., Mremi, A. and colleagues, 2022. Implementation of laboratory quality management systems

in public health facilities in Tanzania. PLOS ONE, 17(2), e0263799.

[27] Mbemba, J., Ndziessi, G. and colleagues, 2026. Knowledge and utilization of laboratory reference intervals among healthcare professionals in Congo. Research Square [Preprint].

[28] Alenazi, A., Alshammari, F., Alotaibi, R. and Alharbi, M., 2023. Professional competency and preparedness among medical laboratory practitioners in Saudi Arabia. Healthcare, 11(10), p.1477.

Appendix A: Questionnaire

Knowledge, Attitudes, and Practices of Medical Laboratory Professionals Regarding the Interpretation of Complete Blood Count Findings Associated with Non-Hematological Conditions in Gezira State, Sudan (2026)

Participant Information and Informed Consent

This questionnaire is part of a postgraduate research study conducted at the University of Gezira. It assesses knowledge, attitudes, and practices among medical laboratory professionals regarding the interpretation of hematological parameters (CBC, ESR, peripheral blood smear) in the context of non-hematological systemic diseases, including infections, liver disease, renal disease, metabolic disorders, and malignancies. Participation is voluntary, anonymous, and confidential; there are no right or wrong answers, and completion takes approximately 20–25 minutes. By proceeding, participants confirm that they have read and understood this information, are qualified medical laboratory professionals currently practicing in Gezira State, and voluntarily consent to the anonymous use of their responses for academic research.

☐ I agree to participate

Section One: Socio-Demographic and Professional Data

1. Age (in completed years)

☐ < 25 years ☐ 25–34 years ☐ 35–44 years ☐ ≥ 45 years

2. Gender

☐ Male ☐ Female

3. Highest academic qualification

☐ Diploma in Medical Laboratory Sciences
☐ Bachelor's degree in Medical Laboratory Sciences
☐ Postgraduate Diploma / Higher Diploma
☐ Master's degree (MSc)
☐ PhD / Doctorate

4. Years of professional experience

☐ < 2 years ☐ 2–5 years ☐ 6–10 years ☐ > 10 years

5. Current primary workplace

☐ Public (government) hospital laboratory
☐ Private hospital laboratory
☐ Primary healthcare / polyclinic laboratory
☐ Private diagnostic laboratory (standalone)
☐ Teaching hospital / university laboratory
☐ Other: _____

6. Current job title / role

☐ Laboratory Technician
☐ Medical Laboratory Scientist / Technologist
☐ Senior / Specialist Laboratory Scientist
☐ Laboratory Supervisor / Head of Department
☐ Other: _____

7. Primary laboratory section

☐ Hematology
☐ Clinical Chemistry / Biochemistry
☐ Microbiology
☐ Blood Bank / Transfusion
☐ Immunology / Serology
☐ Rotational (multiple sections)
☐ Other: _____

8. Specialized training in hematology interpretation (last 5 years)?

☐ Yes, formal in-service training / workshop
☐ Yes, short course or online training
☐ No, self-directed study only
☐ No training at all

9. How frequently do you participate in continuing professional development activities related to laboratory medicine (training courses, workshops, or seminars)?

☐ Never
☐ Rarely (< once/year)
☐ Occasionally (1–2 times/year)
☐ Regularly (≥ 3 times/year)

Section Two: Knowledge Domain

Select the ONE best answer for each question unless otherwise indicated.

K1. A patient with chronic renal failure presents with normocytic, normochromic anemia. The MOST likely mechanism is:

☐ A) Iron deficiency ☐ B) Vitamin B12 deficiency ☐ C) Decreased erythropoietin production ☐ D) Hemolytic destruction of RBCs ☐ E) Bone marrow infiltration

K2. Which CBC finding is MOST characteristic of tuberculosis (TB)?

☐ A) Elevated MCV with normal RDW ☐ B) Low MCV, low MCH, and elevated RDW ☐ C) Normal or slightly low MCV with anemia and monocytosis ☐ D) Elevated MCV with elevated MCH ☐ E) Normal MCV with low platelet count

K3. The neutrophil-to-lymphocyte ratio (NLR) is MOST likely increased in which of the following conditions?

☐ A) Viral infection only ☐ B) Bacterial infection ☐ C) Bone marrow failure ☐ D) Isolated anemia ☐ E) Hypersplenism

K4. In decompensated liver cirrhosis, which CBC combination is MOST expected?

☐ A) Polycythemia, thrombocytosis, leukocytosis ☐ B) Thrombocytopenia, macrocytic anemia, leukopenia ☐ C) Microcytic anemia with elevated WBC ☐ D) Normal CBC with elevated MCV only ☐ E) Isolated neutrophilia

K5. True or False: An elevated RDW in the absence of anemia always indicates pathology and requires immediate clinical action.

☐ True ☐ False

K6. Which ESR value is MOST consistent with active SLE during a flare?

☐ A) 5 mm/hr ☐ B) 12 mm/hr ☐ C) 75 mm/hr ☐ D) 22 mm/hr ☐ E) ESR is not useful in SLE

K7. True or False: In dengue fever, thrombocytopenia typically reflects primary bone marrow failure.

☐ True ☐ False

K8. Which WBC pattern is MOST suggestive of bacterial sepsis?

☐ A) Lymphocytosis with atypical lymphocytes ☐ B) Neutrophilia with left shift (band forms > 10%) ☐ C) Eosinophilia with monocytosis ☐ D) Basophilia with thrombocytosis ☐ E) Neutropenia with lymphocytosis

K9. True or False: Peripheral blood smear (PBS) examination is an essential complement to automated CBC in unexplained cytopenia.

☐ True ☐ False

K10. A patient with Plasmodium falciparum malaria would MOST likely show:

☐ A) Leukocytosis, thrombocytosis, elevated Hb ☐ B) Normal CBC with elevated MCV ☐ C) Anemia, thrombocytopenia, normal or mildly elevated WBC ☐ D) Polycythemia with thrombocytopenia ☐ E) Pancytopenia due to bone marrow failure

K11. A CBC shows MCV = 108 fL with normal MCHC. Peripheral smear shows round macrocytes without hypersegmented neutrophils. Which of the following is the MOST likely cause?

☐ A) Vitamin B12 deficiency ☐ B) Folate deficiency ☐ C) Liver disease ☐ D) Iron deficiency anemia ☐ E) Thalassemia

K12. When interpreting CBC results in patients with non-hematological conditions, the reticulocyte production index (RPI) may be unreliable in which of the following situations?

☐ A) Chronic inflammatory disease ☐ B) Nutritional anemia under treatment ☐ C) Acute infection ☐ D) Splenectomy ☐ E) Iron deficiency anemia

Clinical Scenario 1 (K13–K14): A 60-year-old female with type 2 diabetes and CKD Stage 4. CBC: Hb = 8.8 g/dL, MCV = 84 fL, MCH = 28 pg, RDW = 13.5%, WBC = 6.1 × 10⁹/L, Platelets = 180 × 10⁹/L.

K13. The normocytic, normochromic anemia is MOST likely due to:

☐ A) Bone marrow infiltration ☐ B) Vitamin B12 deficiency secondary to diabetes ☐ C) Reduced erythropoietin production due to CKD ☐ D) Iron deficiency from dietary inadequacy ☐ E) Hemolysis induced by diabetes medication

K14. True or False: The RDW of 13.5% suggests iron supplementation alone would correct this patient's anemia.

☐ True ☐ False

Clinical Scenario 2 (K15): A 28-year-old with a 5-day febrile illness. CBC: WBC = 3.2 × 10⁹/L (lymphocytes 65%), Platelets = 68 × 10⁹/L, Hb = 12.5 g/dL. Peripheral smear shows atypical lymphocytes. NS1 antigen test is positive.

K15. Which interpretation BEST reflects the clinical picture?

☐ A) Bacterial sepsis with reactive thrombocytopenia
☐ B) Dengue fever with leukopenia, lymphocytosis, and thrombocytopenia
☐ C) Malaria with bone marrow suppression
☐ D) Autoimmune thrombocytopenic purpura (ITP)
☐ E) Viral hepatitis with hypersplenism

Section Three: Attitude Domain

Rate your agreement with each statement (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree).

A1. Clinical information on laboratory request forms is essential for accurate CBC interpretation.

1 2 3 4 5

A2. I feel confident interpreting CBC results in patients with chronic systemic diseases.

1 2 3 4 5

A3. Hematological abnormalities on CBC should always be interpreted in the context of the patient's overall clinical status.

1 2 3 4 5

A4. Peripheral blood smear examination provides additional diagnostic value beyond automated CBC analyzers.

1 2 3 4 5

A5. Regular continuing professional development in hematology is necessary to maintain interpretation competence.

1 2 3 4 5

A6. Correlation between hematological findings (CBC) and non-hematological clinical conditions is essential for accurate interpretation.

1 2 3 4 5

A7. Collaboration with clinicians to clarify test results improves patient management outcomes.

1 2 3 4 5

A8. The neutrophil-to-lymphocyte ratio is a clinically useful index I should routinely calculate and report.

1 2 3 4 5

A9. Lack of correlation between hematological results and the patient's clinical condition may lead to misleading laboratory interpretation.

1 2 3 4 5

A10. Providing interpretive comments alongside hematology results adds clinical value to laboratory reports.

1 2 3 4 5

Section Four: Practice Domain

How frequently do you perform each of the following? (5 = Always, 4 = Often, 3 = Sometimes, 2 = Rarely, 1 = Never).

P1. I review clinical information on the request form before interpreting CBC results.

1 2 3 4 5

P2. I add interpretive comments or flags to CBC reports when results suggest a systemic condition.

1 2 3 4 5

P3. I perform or request a peripheral blood smear when CBC results are abnormal or discordant with the clinical picture.

1 2 3 4 5

P4. I contact the requesting clinician to clarify ambiguous results or provide interpretive guidance.

1 2 3 4 5

P5. I calculate or report derived CBC indices (e.g., NLR, Mentzer Index) when clinically relevant.

1 2 3 4 5

P6. I follow a standardized protocol when reporting critical / panic CBC values.

1 2 3 4 5

P7. I differentiate between primary hematological disease and secondary hematological changes in my reports.

1 2 3 4 5

P8. When CBC results show inconsistent values (e.g., high Hb/MCHC) in suspected mixed hyperlipidemia, I recognize lipemic interference and take corrective action (e.g., repeat or sample replacement).

1 2 3 4 5

P9. When CBC shows elevated total WBC (leukocytosis), I determine whether it is primary or reactive and correlate with clinical data before reporting.

1 2 3 4 5

P10. I consider a patient's medication history when interpreting unexpected CBC abnormalities.

1 2 3 4 5

Section Five: Barriers and Challenges

B1. Which barriers affect your ability to accurately interpret hematological results? (Select ALL that apply)

☐ Insufficient training in hematological interpretation
☐ Lack of clinical information on laboratory request forms
☐ Excessive workload / high sample volume
☐ Time pressure limiting detailed result review
☐ Over-reliance on automated analyzer results without manual review
☐ Unavailability of peripheral blood smear microscopy
☐ Poor communication channels with clinical staff
☐ Absence of institutional interpretive reporting guidelines
☐ Limited access to reference materials or clinical guidelines
☐ Insufficient CPD opportunities at my institution
☐ None of the above

Thank you for your participation. Your responses contribute to improving hematological laboratory practice in Sudan.