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ORIGINAL ARTICLE

Knowledge of Healthcare Professionals on Full Blood Count Histogram Interpretation: a cross-sectional study from Ghana

Ruth Duku-Takyi[1*], Mainprice Akuoko Essuman[2], Samira Daud[3], and Felix Osei-Boakye[4,5]

[1]Department of Medical Laboratory Technology, Accra Technical University, Accra, Ghana.

[2]Department of Medical Laboratory Science, School of Allied Health Sciences, College of Health and Allied Sciences, University of Cape Coast, Cape Coast, Ghana.

[3]Department of Biomedical Laboratory Sciences, University for Development Studies, Tamale, Ghana.

[4]Department of Medical Laboratory Technology, Faculty of Applied Science and Technology, Sunyani Technical University, Sunyani, Ghana.

[5]Department of Pharmaceutical Sciences, Faculty of Applied Science and Technology, Sunyani Technical University, Sunyani, Ghana.

*Corresponding author: Ruth Duku-Takyi (rduku-takyi@atu.edu.gh)

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Abstract

Introduction: The full blood count (FBC) is a routine assay that provides information on all the blood cells, such as erythrocytes, leucocytes, and platelets. The FBC results are usually accompanied by histograms which are applicable for making a preliminary prediction of many disease states. In this study, we assessed the utility of FBC histograms among health workers and their knowledge of its interpretation.

Methods: An online quantitative cross-sectional survey designed using Google forms were conducted from April to May 2022. The convenience sampling method was used to invite health workers to the survey that demanded that they answer questions that assessed their levels of utility and knowledge on the interpretation of FBC histograms. Data collected was analysed using the IBM SPSS version 26 using descriptive and inferential statistics.

Results: The final analysis involved responses from 206 health workers who were made up of 133 (64.4%) males and 73 (35.4%) females. The results indicated that a greater portion of respondents makes use of FBC results use FBC analyzers that produce histograms. However, only a small number (30.6%) use FBC histograms in diagnosing patients. A large majority of respondents (80.6%) demonstrated poor knowledge of the FBC histogram with the remaining demonstrating average (14.6%) and good (4.9%) knowledge.

Conclusion: The level of knowledge on FBC histograms is highly inadequate among Ghanaian healthcare professionals and requires urgent attention. We recommend that relevant healthcare professionals should be given continual refresher training on the interpretation of FBC and its histograms to aid in patient management.

Keywords: Full blood count, histograms, health workers, interpretation

Introduction

The full blood count (FBC) is a blood test that is used to evaluate the overall health of an individual and to detect a variety of disorders including anaemia, infection, and various haematological cancers among others (1). It measures the formed elements of blood including the red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs) (2). It is the most commonly requested by as a full blood exam (FBE) or complete blood count (CBC) (3). Usually, it consists of eight to sixteen parameters depending on the haematological analyzer used; that is 3-part or 5-part haematology analyzer (4). The parameters include haemoglobin (Hb), red blood cells parameters such as Red blood cell count (RBC), Mean Cell Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), Red cell Distribution Width (RDW), White Blood Cell parameters such as total white blood cell (WBC) and differential count of neutrophils, basophils, eosinophils, monocytes and lymphocytes, and Platelet count (5). The importance of the FBC test cannot be overemphasized as it is needed routinely in clinical decision-making whenever a patient presents to a medical facility (2). Ultimately, results from the FBC report must be assessed in totality to develop the full clinical significance of the results (6).

Since the advent of automated haematology analyzers, the reporting of FBC has experienced major transformations (7). Many detailed reports regarding cell type and indices are now available to physicians, unlike previously when it was based on counting hundreds of cells using a microscope and then reporting it according to the percentage of each specific cell (8).

The information contained in the full blood count is helpful for physicians in the management of a patient, however, effective utilisation remains a challenge (6).

The FBC histogram is a graphic representation of particle size distribution and is now routinely available on automated cell analyzers as a standard part of automated full blood count (FBC) analysis (9). The use of histograms together with other FBC parameters, such as RDW and MCV abnormalities in various haematological conditions and may also provide major clues in the diagnosis and management of significant red cell disorders (10). It is frequently used, along with the peripheral blood film, in monitoring and interpreting abnormal blood cell morphological changes, especially in dimorphic red cells (5). These generated histograms, which are a very important graphic representation of different populations of cell types remain a neglected piece of information by health care providers (9).

It is important to note that a good interpretation of these histograms provides a wealth of information on many haematological conditions than mere cell counts, helping to narrow down the differential diagnosis at a very early stage even before higher-level investigations are ordered (5). Histogram interpretation needs careful analysis of RBC, WBC, and platelet distribution curves. The histograms are derived by plotting the size of each cell on the X-axis and their relative number on the Y-axis (6).

Unfortunately, due to various reasons which include but are not limited to educational curriculum, insufficient continuous professional development, and negligence of healthcare professionals among full blood count histograms remain rarely used in healthcare practice in Ghana (3). Inadequate knowledge and utilization of these histograms cannot only lead to under or over-diagnosis but also unnecessary repetition in clinical care (10). There is the need to generate empirical data on health workers' use of the FBC histograms in Ghana, and their levels of understanding to formulate continuous training as well as revise

educational curriculums to get the best from FBC results. The present study to the best of our knowledge is the first of its kind in Ghana, which throws light on the indispensable information generated by the FBC histogram.

Materials and Methods

2.1. Study design

A cross-sectional survey was employed and used an online questionnaire survey tool to reach healthcare workers across Ghana. A self-administered questionnaire designed using the authors was delivered online through emails and WhatsApp from May to June 2022.

Sample size determination

A total of 206 participants were recruited using an online convenient sampling method. The convenient sampling method deals with collecting samples by taking samples that are conveniently located around a location or Internet service. The recruitment of participants in this current study was performed online, where structured questionnaires were shared mainly through WhatsApp and emails to participants.

Study population and sampling technique

The study included medical doctors, medical laboratory professionals, nurses, and other healthcare professionals, from different regions in Ghana. Consenting health workers from the various health care settings in Ghana were invited to participate through convenience sampling. Non-healthcare workers and administrative staff were excluded from the study. The study purpose and title were indicated on the front page of the online form, and the participants were requested to avoid multiple entries. The aim, objective, as well as any relevant detail needed by participants concerning the study, were provided on the first page of the form. Participants had the chance to call or email contacts provided in the initial message to seek further clarification.

The recruitment of participants was performed online, mainly through WhatsApp and emails through convenience sampling. The use of an online survey is applauded for being an innovative technique with the advantage of being cost and time-efficient and enabling access to geographically distributed populations such as those targeted in this study (11). We conveniently identified some health workers who meet the study's inclusion criteria and invited them to participate in the study through messages sent via WhatsApp or emails. Approximately, 500 participants were invited to participate; however, a total of 206 health workers (representing 41.2% response rate) with varying backgrounds completed the online survey. Informed consent was obtained from the participants and they were made to understand that their participation was voluntary with them having the chance to redraw at any point. The data generated from this study were anonymized and kept under password protection with only the researchers having access to it. All methods were carried out following relevant guidelines and regulations.

Study instrument

The survey questionnaire and its content were developed by the researchers after reviewing relevant literature, discussing it with professionals, and undertaking a pilot study. To get a desirable outcome, the questionnaire was shared among immediate colleagues to scrutinize the accessibility, clarity, and relevance of the survey questions.

The final questionnaire in English had 25 questions divided into three parts. The first part of the questionnaire had eight questions and elicited information on participants' demographic characteristics such as age, and gender, and sought to collate data on participants' profession and experience. Questions asked participants to provide their profession, place of work, years in service, and the highest level of academic achievement. The second part contained seven questions that aimed at knowing participants' usage, exposure, and perception of the FBC histograms. With this, participants were asked whether they use FBC results in diagnosis, whether the FBC analyser at their facility provides histograms, whether they believe FBC histograms are relevant and whether they were taught FBC histograms as part of their training. Those who indicated that they have received training on FBC histograms were asked to indicate the nature of the training. The last part consisted of 10 multiple choice questions related to knowledge of FBC histogram interpretation. Participants were asked to select from questions with five options (A-E), some basic principles concerning the FBC histogram as well as the interpretation of different histograms for different disorders.

Data processing and analysis

Responses were collected in Microsoft Excel 2016 and analysed using the IBM Statistical Package for Social Sciences, version 26 (Chicago, IL, USA). Descriptive statistics such as frequencies, percentages, and means were used to summarize the background characteristics of participants as well as their exposure to the FBC histograms. The Shapiro–Wilk tests was used to verify normality.

Health workers' knowledge of the FBC histogram interpretation was determined on a scale of 10 multiple choice questions. Each correct answer was allocated one point, and a wrong answer attracted no point. Questions that were not answered or given an "I don't know" response was treated as wrong answers. A total score on knowledge was calculated for each participant from these 10 multiple choice items and the correct answers were converted to 100%. Participants' knowledge of FBC histograms was categorized based on their total score on the knowledge scale as follows: good knowledge (80% or higher), average knowledge (50%-79%), and poor knowledge (less than 50%). The assumption of homogeneity of variances was tested using Levene's test. The one-way analysis of variance (ANOVA) and the independent sample t-test was used to examine differences in knowledge between participant characteristics. Where variances were not homogenous based on Levene's test, the Welch test followed by the Games-Howell post hoc analysis was used to make comparisons. Variables with p-values less than 0.05 in the bivariate analysis were included in a binary logistic regression analysis to identify possible determinants of average to good knowledge in FBC histogram interpretation. For all analyses, a p-value less than 0.05 was considered significant.

Results

Characteristics of respondents

The final analysis involved responses from 206 health workers who were made up of 133 (64.4%) males and 73 (35.4%) females. Most of the respondents were between 21-30 years with an average age of 31.49 ± 5.37 years (range: 21-55 years) and had been working in their current profession for an average of 5.8 years (range: 1-28 years). More than half of the respondents were medical laboratory professionals (54.9%) with the majority (51.5%) having a degree (**Table 1**).

Exposure and use of the full blood count histograms

Participants were asked questions that allow them to indicate their exposure to or previous learning experience of the FBC histogram. The results as shown in **table 2** indicated that a greater portion of respondents make use of FBC results (94.7%), and uses FBC analyzers that produce histograms (73.8%), however, only a small number (30.6%) use FBC histograms in diagnosing patients. Almost half (45.6% [94]) of the respondents had received training on FBC histograms, however, the scope and duration of the training were superficial and brief for 72.3% of such respondents.

Knowledge of the full blood count histogram

Table 3 summarizes the response rate for items used to assess knowledge of FBC histogram interpretation in the present study. Out of a possible range of scores from 0 to 100, respondents had an overall average score of 18.35 ± 25.8%. A large majority of respondents (80.6%) demonstrated poor knowledge of the FBC histogram with the remaining demonstrating average (14.6%) and good (4.9%) knowledge. More than half of the respondents (52.9%) could not answer any of the 10 study items. The questions that received the most correct answers were those on features of the histogram such as what the X-axis (28.2%) and Y- axis (24.8%) represent. However, questions that assessed respondents' knowledge of the application of the FBC histograms in various medical conditions were poorly answered. **Figure 1** shows the images used in the questionnaire.

Differences in health workers' knowledge of FBC histogram based on characteristics

Table 4 summarizes the results of comparisons of knowledge of FBC histograms among respondents based on their characteristics using the bivariate analysis. bivariate analysis showed that Gender, use of FBC results, use of an FBC analyzer that produces histograms, use of FBC histograms in diagnosis, and receiving training on FBC histograms were statistically associated with knowledge of FBC histogram interpretation. The ANOVA and Welch results showed that there were significant differences between health workers' knowledge in terms of their profession ($F=20.31$, $p<0.001$), and qualification ($F=2.56$, $p=0.002$).

A Games-Howell post hoc test revealed that the knowledge of medical laboratory professionals about FBC histogram interpretation (29.29±27.64) was significantly higher than medical doctors (7.50±21.19, $p<0.001$), nurses/ midwives (4.34±13.38, $p<0.001$), physician assistants (2.86±4.88, $p<0.001$) and other health workers (2.00±4.47, $p<0.001$).

Health workers holding bachelor's degrees (22.74±26.37) were more knowledgeable about FBC histogram than those who had to attain either a diploma (10.61±18.64, $p=0.011$) or MBChB/MBBS (6.82±20.79, $p=0.028$). There were no significant differences in the levels of knowledge of health workers based on age, years in service, place of work, and nature of training on FBC histogram received.

Predictor variables for health workers' knowledge of FBC histogram

The binary logistic regression analysis showed that compared to medical doctors, laboratory professionals were 3.59 times more likely to have average to good knowledge of FBC histograms. In addition, the use of an FBC analyzer that produces histograms, understanding histograms attached to test results, use of FBC histograms in diagnosis, and receiving training on FBC histograms were significantly associated with having average to good knowledge of the FBC histogram (OR: 8.67, 95% CI: 2.01-37.29; OR: 14.52, 95% CI: 5.39-39.14; OR: 4.26, 95% CI: 2.07-8.76; and OR: 3.07, 95% CI: 1.48-6.37) as seen in **table 5**.

Table 1: Distribution of characteristics of health workers involved in the study (N=206)

Variable	Categories	Frequency	Percentage
Age (years)	21-30	108	52.4
	31-40	84	40.8
	>40	14	6.8
Gender	Female	73	35.4
	Male	133	64.6
Profession	Medical doctor	28	13.6
	Nurse/midwife	53	25.7
	Medical Laboratory professional	113	54.9
	Physician assistant	7	3.4
	Others*	5	2.4
Years of practice	≤5	126	61.2
	6-10	45	21.8
	>10	35	17
Place of work	Ghana Health Service	85	41.3
	Mission Hospital	46	22.3
	Private Hospital	18	8.7
	Quasi-Government hospital	14	6.8
	Teaching Hospital	43	20.9
Qualification	Certificate	10	4.9
	Diploma/HND	49	23.8
	Degree	106	51.5
	MBChB/MBBS	22	10.7
	Masters/PhD	19	9.2

*Other health workers included pharmacists (3), health promotion officers (1), and disease control officers (1).

Table 2: Exposure to the full blood count histogram (N=206)

Variable	Categories	Frequency	Percentage
Makes use of FBC results	No	11	5.3
	Yes	195	94.7
FBC analyzer produces histograms	No	54	26.2
	Yes	152	73.8
Thinks FBC histograms are relevant	No	20	9.7
	Yes	186	90.3
Understands histograms attached to results	No	117	56.8
	Yes	89	43.2
Uses FBC histograms in diagnosis	No	143	69.4
	Yes	63	30.6
Received training on FBC histograms	No	112	54.4
	Yes	94	45.6
Nature of training	Brief and superficial	68	72.3
	Thorough but without any demonstration	8	8.5
	Thorough with demonstration	18	19.1

The analysis for the question on the nature of the training involved 94 respondents who indicated that they had received training on FBC histograms

Table 3: Health workers' knowledge of full blood count histogram interpretation.

Study questions	Correct answers n (%)	Incorrect answers n (%)
1. What does the X-axis of the FBC histogram represent?	58 (28.2)	148 (71.8)
2. What does the Y-axis of the FBC histogram represent?	51 (24.8)	155 (75.2)
3. What does A in the diagram stand for?	42 (20.4)	164 (79.6)
4. What does B in the diagram stand for?	61 (29.6)	145 (70.4)
5. What does C in the diagram stand for?	35 (17.0)	171 (83.0)
6. The histogram above represents?	27 (13.1)	179 (86.9)
7. What abnormality does the above histogram represent?	41 (19.9)	165 (80.1)
8. What abnormality does the above graph represent?	27 (13.1)	179 (86.9)
9. This graph can be seen in the following conditions except?	12 (5.8)	194 (94.2)
10. The graph can be seen in what condition?	24 (11.7)	182 (88.3)

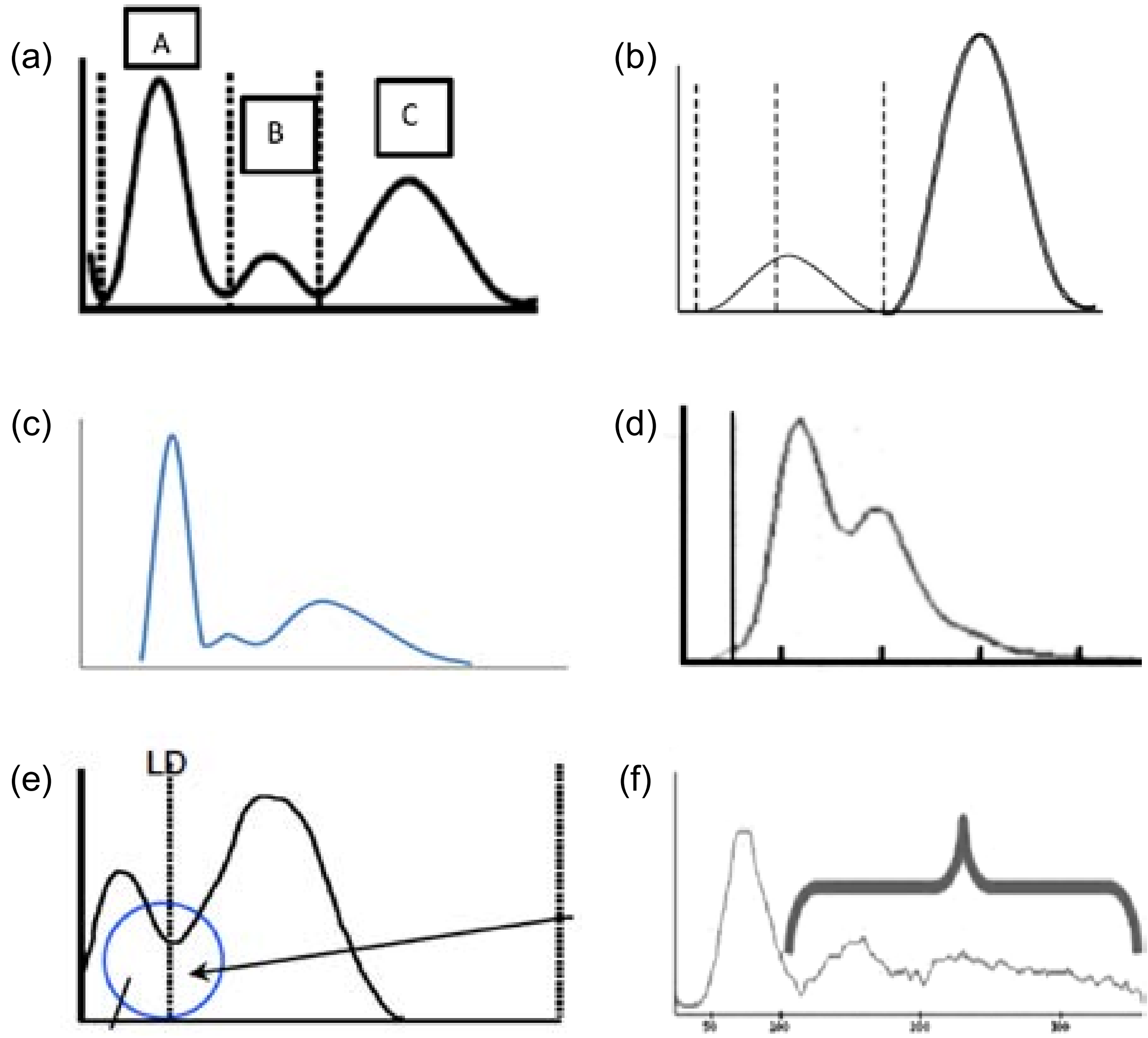

Figure 1: Images used in forming study. Questions 3,4 and 5 (a); Question 6(b); Question 7 (c); Question 8(d); Question 9(e); and Question 10(f)

Table 4: Comparison of health workers' knowledge of the full blood count histogram based on demographic factors and exposure to FBC histograms using univariate analysis.

Variable	Mean Score	SD	F/t statistic	p-value
Age groups				
21-30	15.65	23.73	1.30[a]	0.275
31-40	20.95	27.58		
>40	23.57	30.79		
Gender				
Female	11.78	22.69	-2.88[b]	**0.005**
Male	21.95	26.90		
Profession				
Medical doctor	7.50	21.19	20.31[c]	**<0.001**
Nurses/midwives	4.34	13.38		
Medical laboratory professional	29.29	27.64		
Physician assistant	2.86	4.88		
Others	2.00	4.47		
Years of practice				
≤5	14.60	23.31	3.13[c]	0.050
6-10	24.67	29.36		
>10	23.71	28.19		
Place of work				
Ghana Health Service	16.35	24.97	0.86[c]	0.494
Mission Hospital	21.09	28.07		
Private Hospital/Laboratory	12.78	15.65		
Quasi-government hospital	17.86	26.65		
Teaching Hospital	21.86	28.64		
Qualification				
Certificate	7.00	18.89	2.56[c]	**0.002**
Diploma/HND	10.61	18.64		
Degree	22.74	26.39		
MBChB/MBBS	6.82	20.79		
Masters/PhD	33.16	34.97		
Makes use of FBC results				
No	0.00	0.00	10.32[b]	**<0.001**
Yes	19.38	26.24		
FBC analyzer produces histograms				
No	6.30	17.62	5.03[b]	**<0.001**
Yes	22.63	27.03		
Thinks FBC histograms are relevant				
No	4.00	13.92	4.34[b]	**<0.001**

Yes	19.89	26.43		
Understands histograms attached to results				
No	5.38	13.43	9.21[b]	**<0.001**
Yes	35.39	28.41		
Uses FBC histograms in diagnosis				
No	11.89	20.89	5.07[b]	**<0.001**
Yes	33.02	30.03		
Received training on FBC histograms				
No	10.89	22.40	4.67[b]	**<0.001**
Yes	27.23	27.06		
Nature of training				
Brief and superficial	25.15	26.85	0.74[c]	0.737
Thorough but without any demonstration	31.25	17.27		
Thorough with demonstration	33.33	31.25		

[a]One – way analysis of variance (ANOVA); [i]ndependent sample t-test; [c]Welch test, FBC – full blood count; SD – standard deviation

Table 5: Logistic regression predicting health workers' knowledge of FBC histogram interpretation

Variable	n (%) with acceptable to excellent knowledge	OR	95% CI	p-value
Gender				
Female	11 (15.1)	1		
Male	29 (21.8)	1.57	0.73-3.37	0.245
Profession				
Medical doctor	3 (10.7)	1		
Nurse/midwife	3 (5.7)	0.50	0.09-2.66	0.416
Laboratory professional	34 (30.1)	3.59	1.01-12.69	**0.048**
Physician assistant	0 (0.0)			
Others	0 (0.0)			
Qualification				
Certificate	1 (10.0)	1		
Diploma/HND	5 (10.2)	1.02	0.11-9.84	0.984
Degree	24 (22.6)	2.63	0.32-21.85	0.37
MBChB/MBBS	2 (9.1)	0.90	0.07-11.25	0.935
Masters/PhD	8 (42.1)	6.55	0.69-62.59	0.103
FBC analyzer produces histograms				
No	2 (3.7)	1		
Yes	38 (25.0)	8.67	2.01-37.29	**0.004**
Thinks FBC histograms are relevant				
No	1 (5.0)	1		
Yes	39 (21.0)	5.04	0.65-38.83	0.120
Understands histograms attached to results				
No	5 (4.3)	1		
Yes	35 (39.3)	14.52	5.39-39.14	**<0.001**
Uses FBC histograms in diagnosis				
No	17 (11.9)	1		
Yes	23 (36.5)	4.26	2.07-8.76	**<0.001**
Received training on FBC histograms				
No	3 (11.6)	1		
Yes	27 (28.7)	3.07	1.48-6.37	**0.003**

OD – odds ratio; CI – confidence interval;

Discussion

The full blood count (FBC) is a routinely available assay that provides information on all the blood cells, viz: erythrocyte, leucocyte, and platelets. The relevance of the FBC histogram is applicable in the detection of blood clots in specimens, and for making a preliminary prediction of disease states like anaemia, leukaemia, thalassaemia, polycythaemia, infections, immunosuppression, thrombocytopenia, among others (4). In this study, we assessed the knowledge of healthcare professionals in utilizing FBC histogram and its interpretation. This was to help identify knowledge gaps that hinder the utilization of FBC histograms for patient management.

Approximately, 95% of the respondents utilised FBC results in patient management, which confirms how frequently the FBC assay is requested (12) worldwide, including in Ghanaian hospitals. However, the proportions of the respondents that understood and utilised the FBC histogram, one of the two major components of the test results, were less than half (43.2% vs 30.6%, respectively) in each case. This is consistent with a study conducted by Sandhaus and Meyer (13), which attributes the minimal utilisation of the FBC histogram result to the style of presentation which makes it difficult for healthcare professionals to understand. To further buttress this assertion, Sandhaus and Meyer (13) posit that the modern automation in diagnostic equipment design has led to the development of more analyzer-derived biomarkers that make the FBC histogram reports complicated. Ramifications of this are that physicians are presented with a lot of data they may not understand and may therefore, may interpret it wrongly (12) or fail to utilise it, which further compromises the quality of patient care.

In Ghana, healthcare authorities ensure a continual refresher capacity building of health staff through the Continuous Professional Development (CPD) program. However, it is important to note that there is diversity in the health professions, and the scope of training of each cadre of staff is different. Since all the health staff does not share a common educational background, it is difficult for the different professions to appreciate the nature of haematology-related CPD programs.

The proportion of the respondents that correctly answered the set of questions was less than 30.0% and highly inadequate, which raises concerns about the accuracy of the diagnosis and management given to patients in the various hospitals in Ghana. The knowledge of health workers on FBC histograms was increased in older (>40 years) respondents and those with 6-10 years of working experience, although not significant. It is expected that older respondents have worked for a considerably longer duration and are more experienced. However, in Ghana, most healthcare professionals are promoted to managerial ranks after 10 years of practice, which can make them pay less attention to their core mandates. This consequently explains why the level of knowledge declined after 10 years. The knowledge was significantly increased in Medical Laboratory Scientists (MLS) and postgraduate degree holders, but not medical doctors. This corroborates the findings of another study conducted in Ethiopia by Birhaneselassie *et al*., (12), which reported inadequate knowledge of FBC in different cadres of medical doctors. Moreover, Birhaneselassie *et al*., (12) attributed their findings to the increased number of specialist physicians among their respondents and further suggested that specialist training restricts professionals to a few aspects of the profession.

Although the level of knowledge was significantly increased in respondents who made use of FBC results ($p<0.001$), whose analysers produce histograms ($p<0.001$), think histograms are relevant ($p<0.001$), understand histograms ($p<0.001$), utilise histograms ($p<0.001$) and received training on FBC ($p<0.001$), the mean knowledge was not encouraging, with each below 40.0%. There is an urgent need for the health workforce to upgrade to bridge this huge knowledge gap to ensure quality care to patients.

Overall, knowledge of the healthcare professionals on FBC histograms was inadequate, with 80.6% showing poor knowledge. This was contrary to the findings of a study conducted in Brazil by De Almeida *et al*., (14), which reported rather increased mean responses. In Ghana, health workers are faced with several deficiencies including equipment, human resources needed to make the right diagnosis and management of patients, whereas Brazil is a developed country with the basic resources needed for patient care. These resource limitations of Ghana may also affect the nature of the training of the health workers. This may account for the variation in the findings between the two studies. Furthermore, De Almeida *et al*., (14), attribute this to the complex nature of the FBC histogram and the fact that the results can suggest a myriad of pathologies spanning several disciplines. In this study, more than half (54.4%) of the respondents had no requisite training on FBC histograms. It is worthy to note that the practice of each healthcare profession is governed by a different curriculum in which the scope of training is enshrined. Furthermore, the FBC test is a haematological assay and only professionals that have this specialty forming part of their curriculum may be knowledgeable. According to De Almeida *et al.*,(14), although information on clinical decisions is reserved for physicians, the role of other health workers in the success of a diagnosis cannot be underestimated.

This study, however, was limited by the fact that it failed to assess the area of specialty/ postgraduate study the respondents had. There was limited participation in the study which limits the generalizability of the findings of the study. We are of the view that the number of people who refused to participate in the study possibly had limited knowledge of the study items. However, the findings of the study highlight a gap in health workers interpretation of FBC histograms necessitating the need for education.

Conclusion

The level of knowledge on FBC histograms is inadequate among Ghanaian healthcare professionals. Medical Laboratory Scientists and postgraduate degree holders were more likely to be knowledgeable than the other groups. We, therefore, recommend that relevant healthcare professionals require continual refresher training on the interpretation of FBC and its hemogram reports if they are to be fully utilised in patient management.

Data Availability

The dataset supporting the conclusions of this study is available with the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no competing interests.

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Authors' Contributions

RDT, MAE, SD, and FOB contributed equally in conceptualising and designing the study, data collection and management, and writing the draft and final manuscript. Statistical analysis was performed by MAE. All authors read and approved the final manuscript.

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