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RESEARCH ARTICLE

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Evaluation of hematological indices of childhood illnesses in Tamale Metropolis of Ghana

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Background: Although hematological indices cannot in entirety be used to diagnose diseases or defects, the appropriate interpretation of these indices could complement diagnostics such as microscopy and serology for numerous illnesses in children. This study sought to evaluate distinct hematological indices characterizing different childhood illnesses.

Methods: Full blood counts from 150 children (age range from 1 to 15 year) presenting different disease conditions at the Tamale Central Hospital were assessed. The hematological indices were compared between disease categories, and relationships between disease indicators were determined.

Results: The prevalence of the diagnosed childhood illness were: 50.7% malaria, 20.0% diarrhea, 13.3% typhoid fever, 10.0% Sickle Cell Disease (SCD), and 6.0% malaria-typhoid co-infection. Fever was diagnosed in a majority (66.0%) of the children, but was independent of each disease group, ($\chi^2 = 9.18$, $P = .057$). Of the 24 hematological indices analyzed, eight; red blood cell (RBC) ($P < .001$), hemoglobin (Hb) ($P < .001$), mean cell volume (MCV) ($P = .002$), mean cell hemoglobin (MCH) ($P < .001$; lowest and below normal range for SCD), red cell distribution width (RDW_CV) ($P < .001$), eosinophil percentage [EOS (%)] ($P = .001$), eosinophil number [EOS#] ($P = .002$), and platelets (PLT) ($P = .001$; lowest for malaria) differed significantly across the different disease groups. Levels of Hb and/or MCV were below the normal reference ranges for most of the diagnosed diseases. In addition, low PLT and MCH were respectively distinct for children with malaria and SCD.

Conclusion: Hematological indices including Hb, MCV and PLT, or MCH may be useful indices that could incite further diagnostic tests for malaria or SCD among children in Ghana.

KEYWORDS
hematological indices, malaria, sickle cell disease, typhoid fever

1 | INTRODUCTION

Child morbidity and mortality are issues confronting all developing countries and, in Ghana various strategies have been put in place by the Ghana Health Service (GHS) to curb this menace. Various illnesses and disease symptoms, including acute respiratory infection (ARI), fever, and dehydration from diarrhea are important contributing causes of childhood morbidity and mortality in developing

countries,[1] and prompt medical attention including laboratory diagnosis are paramount in reducing deaths and morbidities caused by these illnesses.

The accuracy and appropriate interpretation of hematological tests are important in the diagnosis of various illnesses and also for investigating the extent of damage to blood.[2] Hematological profiles when interpreted in accordance with the history of a disease help clinicians in the selection of diagnostics and to unravel or confirm the disease condition. These hematological profiles provide an important overview of the well-being of an individual and can be used to trace background conditions related to blood and blood forming organs.

Many factors affect the values of hematological parameters in children,[3-7] with infections by pathogens being a major determinant. Evidence indicates that there are alterations in hematological values in Ghanaian children with malaria.[8,9] These changes usually affect the red cells, platelets, and leukocytes, thus causing anemia,[8,9] thrombocytopenia,[10] and leukopenia,[11] respectively. Typhoid infection also alters hematological profiles causing anemia, leukopenia, eosinopenia, and thrombocytopenia.[12,13]

The laboratory diagnosis of most childhood illnesses in many settings in Ghana relies on serology and microscopy. While serology has drawbacks with respect to sensitivity and specificity, microscopy results are marred by human errors. On the other hand, full blood count analysis by the automated machines provides readily obtainable, accurate and reliable results. In this view, the study evaluated distinct hematological indices that could trigger further probing for common childhood illnesses in the Tamale Metropolis of Ghana

2 | MATERIALS AND METHODS

2.1 | Study design, study site and population

The study used a hospital-based cross-sectional design, targeting children between the ages of 1-15 years who presented different disease conditions at the Tamale Central Hospital (TCH) from February to April 2015. The Hospital is located in the central Tamale township; the northern regional capital of Ghana and serves nearly 240 000 people.

2.2 | Ethical consideration

Ethical approval for the study was obtained from the School of Medicine and Health Sciences (SMHS) and the School of Allied Health Sciences (SAHS) joint Institutional review board of the University for Development Studies, Ghana. A letter of approval was obtained from the TCH which enabled the study to commence. Individual written informed consent was provided by the parents of all study participants and in addition, child accent were obtained from study participants who were ≥7 year.

2.3 | Demographic and clinical data collection

A standardized questionnaire on demographic data was filled out for each study participant. The common Clinical symptoms: vomiting, loss of appetite, bodily pains and weakness, and chills, based on the clinician's examination during consultation were collected from patients' folders by the clinicians on duty.

2.4 | Sample collection

A vacutainer EDTA tube was used to collect 3 mL of venous blood sample from each participant for laboratory investigations using the automated blood cell analyzer Sysmex XS-500i (Sysmex Corporation, Kobe, Japan).

2.5 | Diagnosis of fever, determination of hematological reference ranges and cytopenias

Fever was diagnosed based on axillary temperature ≥37.5°C; in accordance with WHO criteria. Hematological reference ranges were determined based on the automated blood cell analyzer's lower and upper cut-off values. Anemia was diagnosed by Hb<11, Hb<15, and Hb<12 for children within the ages of 1-5 years, 6-10 years, and 11-15 years, respectively.[14] Thrombocytopenia and Leukopenia were determined by platelet and WBC counts $<150 \times 10^3/\mu L$ and $<3 \times 10^3/\mu L$, respectively; in accordance with the automated blood cell analyzer's lower cut-off values.

2.6 | Malaria diagnosis

CareStart Malaria HRP-2 rapid diagnostic test (Access Bio) was used to screen for the presence of malaria parasites. Briefly, a drop (5 μL) of participant's blood was dispensed on the sample pouch of the test cassette, two drops of the sample diluent were immediately added to the diluent porch and result read and interpreted after 15-min, following the manufacturer's protocol. Subsequently, microscopy was used to detect and confirm the presence of malaria parasites examining thick blood smears stained with 20% Giemsa solution at pH 7.2.

2.7 | Detection of sickling status

Sickling test was used for the diagnosis of sickle cell disease. In determining the sickling status, 1 drop of blood was mixed with 1 drop of 2% sodium metabisulphite solution on a microscope slide, with a cover slip placed on it. This was then allowed to stand at room temperature for 30 min before being examined under the microscope with x40 objective lens. All microscope positive samples were later genotyped by Hb electrophoresis according to manufacturer's instructions (Helena Laboratories, Beaumont, TX, USA). Briefly, the lysis buffer (0.005 M EDTA with 0.01% potassium cyanide) was used to hemolyse patient's whole blood. Control samples

(AA, AS, SC, and SS) and patient hemolysates were next blotted on to cellulose paper and placed in the electrophoresis machine containing Tris-EDTA/boric acid buffer at a pH of 8.4 and ionic strength of 0.035. Electrophoresis was done at 350 V for 25 minutes. The sickle cell genotypes were identified by comparing sample bands to control bands.

2.8 | Diagnosis of typhoid Fever

The Widal test was used to diagnose typhoid fever using commercially available kits (HUMAN DIAGNOSTIC, Germany). Briefly, plasma was pipetted in sequential titres (40 μL, 20 μL, 10 μL, and 5 μL) and placed on each ring of the clean rocking plate. One drop of antigen-O and antigen-H of *Salmonella typhi* were each added to their respective ring with the plasma titres. These were mixed and rocked and agglutination observed. Results were read according to the titre of plasma in which agglutination occurred.

2.9 | Diagnoses of diarrheal diseases

Diarrhea was diagnosed in accordance with the WHO criteria; that is, if a child had loose or watery stools at least thrice daily, or if a child had more frequent stools than in a normal individual.[15,16]

2.10 | Hematological analysis (full blood count)

A full range of hematological parameters: RBC: Red blood cell, HCT: Hematocrit, Hb: Hemoglobin, MCV: Mean cell volume, MCH: Mean cell hemoglobin, MCHC: Mean cell hemoglobin concentration, RDW_CV and RDW_SD: Red cell distribution width, WBC: White blood cell, LYM (%): Lymphocyte percentage, LYM#: Lymphocyte number, NEUT (%): Neutrophil percentage, NEUT#: Neutrophil number, MONO(%): Monocyte percentage, MONO#: Monocyte number, EOS(%): Eosinophil percentage, EOS#: Eosinophil number, BASO(%): Basophil percentage, BASO#: Basophil number, PLT: Platelets, MPV: Mean platelet volume, PDW: Platelet distribution width and PCT: Procalcitonin and P-LCR: Platelet larger cell ratio, were determined using the automated blood cell analyzer, Sysmex XS-500i (Sysmex Corporation, Kobe, Japan).

2.11 | Statistical analysis

Categorical variables were presented as frequencies and percentages whilst continuous variables were described with median, range and interquartile range (IQR). The Pearson's chi-square test was used to compare categorical variables whilst continuous variables were compared by Kruskal-Wallis one-way analysis of variance. All comparisons with $P < .05$ were considered as statistically significant. Data were analyzed using Graphpad Prism 7.03 (GraphPad Software Inc.) and SPSS Version 20 (IBM Corporation, Chicago, USA).

3 | RESULTS

3.1 | General characteristics of the study participants

Out of the 150 children studied, 77 (51.3%) were males and the rest were females, however, no gender difference was observed within each disease category ($\chi^2 = 8.63$, $P = .065$), Table 1. The median age of the children was 3-y (IQR: 2-8 years); age was found to be similar amongst the children in the different disease categories ($P = .059$) (Table 1). The most prevalent single disease condition observed was malaria (50.7%), followed by diarrhea (20.0%), typhoid (13.3%) and sickle cell disease (10.0%); genotyping revealed that all the sickling positive children were HbSS (Table 1). The prevalence of malaria and typhoid co-infection was 6.0% (Table 1). Even though it was observed that each of the disease conditions was most prevalent in the 1-5 years age group, this relationship was not statistically significant ($\chi^2 = 8.64$, $P = .374$; Table 1). The median body temperature in the entire group was 38.0°C (IQR: 37.1-39.0°C), however, it was observed that children with either malaria or SCD had significantly higher body temperatures ($P = .021$ respectively) compared to the other disease categories (Table 1). A majority (99%, 66.0%) of the children had fever, which was common for all the disease groups and not unique to any particular disease category ($\chi^2 = 9.18$, $P = .057$; Table 1). With diagnosis of cytopenias amongst the children, anemia was found to be the most prevalent condition (68.7%), followed by thrombocytopenia (46.0%) whilst leukopenia, was the least common (2.6%, Table 1). Thrombocytopenia was found to be significantly associated ($\chi^2 = 16.83$, $P < .001$) with malaria, whilst anemia and leukopenia were independent of each disease category (Table 1).

3.2 | Common clinical symptoms among children with various illnesses

Results of clinical examination revealed that most of the children in each disease category had multiple symptoms (Table 2). Vomiting was the commonest symptom amongst the children (38.7%), and was found to be most prevalent in children with malaria ($\chi^2 = 10.88$, $P = .028$; Table 2). Loss of appetite was observed in 19.3% of the children and was found to be significantly associated with children with diarrheal disease ($\chi^2 = 28.74$, $P < .001$), Table 2. Bodily pains and weakness, and chills were observed in 10.3% and 7.3% children, respectively, and were independent of each disease group [($\chi^2 = 4.64$, $P = .326$) and ($\chi^2 = 1.64$, $P = .802$), respectively], Table 2.

3.3 | Hematological profiles for children with the different categories of diseases

Most of the hematological parameters analyzed for the different disease categories were within the normal reference range using the Sysmex XS-500i analyzer, except for Hb and MCV in children with malaria or with malaria-typhoid co-infection; MCV in children with typhoid fever; and Hb, MCV, and MCH in children with SCD; which fell below the reference ranges (Table 3). Comparison of the median

hematological values between the disease categories revealed that 8 out of the 24 hematological parameters differed across the groups, (RBC, Hb, MCV, MCH, RDW_CV, EOS (%), EOS#, and PLT) (Table 3). It was observed that children with malaria had significantly lower red cell parameters (RBC, Hb, MCV, and RDW_CV) and platelet counts as compared to the other disease categories (Table 3). The median

TABLE 1 Characteristics of study population by different disease conditions

Characteristics	Mal N = 76	Typ N = 20	SCD N = 15	Mal + Typ N = 9	Diarrhea N = 30	*P**
Age, years, median (IQR)	4.0 (2.0-8.0)	6.5 (3.0-11.0)	2.0 (1.0-7.0)	3.0 (1.5-7.0)	2.0 (1.0-7. 5)	.059
Age category, years, n (%)						
1.0-5.0	41 (27.3)	8 (5.3)	11 (7.3)	5 (3.3)	18 (12.0)	.374
6.0-10.0	24 (16.0)	7 (4.7)	4 (2.7)	3 (2.0)	5 (3.3)	
11.0-15.0	11 (7.3)	5 (3.3)	0 (0.0)	1 (0.7)	7 (4.7)	
Gender; n (%)						
Male	39 (51.3)	5 (25.0)	10 (66.7)	4 (44.4)	19 (63.3)	.065
Female	37 (48.7)	15 (75.0)	5 (33.3)	5 (55.6)	11 (36.7)	
Temperature, °C, median (IQR)	38.3 (37.4-39.3)	37.5 (36.9-38.7)	38.3 (37.3-39.0)	37.5 (36.8-39.3)	37.4 (36.6-38.3)	.021
Fever diagnosed (%)						
Yes	57 (75.0)	11 (55.0)	11 (73.3)	6 (66.7)	14 (46.7)	.057
No	19 (25.0)	9 (45.0)	4 (26.7)	3 (33.3)	16 (53.3)	
Anemia (%)						
Yes	55 (72.4)	12 (60.0)	9 (60.0)	7 (77.8)	20 (66.7)	.716
No	21 (27.6)	8 (40.0)	6 (40.0)	2 (22.2)	10 (33.3)	
Thrombocytopenia (%)						
Yes	47 (61.8)	2 (10.0)	7 (46.7)	3 (33.3)	10 (33.3)	<.001
No	29 (38.2)	18 (90.0)	8 (53.3)	6 (66.7)	20 (66.7)	
Leukopenia (%)						
Yes	2 (2.6)	0 (0.0)	1 (6.7)	0 (0.0)	1 (0.8)	.778
No	74 (97. 4)	20 (100.0)	1 (93.3)	9 (100.0)	29 (96.7)	

**P*; analyzed by Kruskal-walis test, Pearson chi-square test or Fisher exact test, Mal- children infected with malaria parasites, Typ- children with salmonella infection, SCD- children with HbSS, Mal + Typ- children with malaria parasites and salmonella co-infection, Diarrhea- children with diarrheal diseases

TABLE 2 Distribution of clinical symptoms across the different groups of children

Clinical symptoms	Mal N = 76	Typ N = 20	SCD N = 15	Mal + Typ N = 9	Diarrhea N = 125	*P**
Vomiting; n (%)						
Yes	37 (48.7)	5 (25.0)	3 (20.0)	5 (55.6)	9 (30.0)	.028
No	39 (51.3)	15 (75.0)	12 (80.0)	4 (44. 4)	21 (70.0)	
Loss of Appetite; n (%)						
Yes	7 (9.2)	2 (10.0)	3 (20.0)	1 (11.1)	16 (53.3)	<.001
No	69 (90.8)	18 (90.0)	12 (80.0)	8 (88.9)	14 (46.7)	
Bodily pains and weakness; n (%)						
Yes	10 (13.2)	2 (10.0)	3 (20.0)	0 (0.0)	1 (3.7)	.326
No	66 (86.8)	18 (90.0)	12 (80.0)	9 (100.0)	29 (96.7)	
Chills; n (%)						
Yes	6 (7.9)	2 (10.0)	0 (0.0)	1 (11.1)	2 (8.7)	.802
No	70 (92.1)	18 (90.0)	15 (100.0)	8 (88.9)	28 (93.3)	

**P*; analyzed by Pearson chi-square test or Fisher exact test, Mal- children infected with malaria parasites, Typ- children with salmonella infection, SCD- children with HbSS, Mal + Typ- children with malaria parasites and salmonella co-infection, Diarrhoea- children with diarrheal diseases.

TABLE 3 Comparison of ranges and median hematology values among children with various diseases in Tamale

	Mal (N = 76)		Typ (N = 20)		SCD (N = 15)		Mal + Typ (N = 9)		Diarrhea (N = 30)		Reference	
Analyte (unit)	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	*P**
RBC (10^6/μL)	1.31-6.33	4.03	3.09-5.91	4.65	4.00-6.20	4.71	4.04-5.82	4.44	1.91-6.11	5.02	2.50-5.50	<.001
Hb (g/dL)	7.5-12.1 L	10.1	10.0-17.2	12.9	9.5-12.4 L	11.4	8.2-11.8 L	10.2	7.9-15.9	10.6	13.0-18.0	<.001
HCT (%)	13.1-43.3	31.2	24.4-51.0	35.9	28.3-85.9	33.1	28.5-44.9	32.1	7.6-54.4	33. 5	26.0-50.0	.0519
MCV (fL)	51.3-85.9 L	69.6	56.9-84.7 L	80.1	22.5-81.5 L	72.9	56.7-85.2 L	78.4	54.4-91. 5	72.8	86.0-110.0	.002
MCH (pg)	15.0-34.5	25.7	17.6-29.4	25.9	15.3-25.6 L	21.7	20.7-32.5	25.2	14.8-29.9	23.4	26.0-36.0	<.001
MCHC (g/dL)	25.4-38.3	31.2	27.2-38.0	31.7	123.0-34.9	30.4	26.0-35.0	31.8	22.3-38.9	30.0	25.4-37.6	.279
RDW_CV (%)	12.40-29.8	14.8	12.5-24.5	15.8	14.2-25.5	20.0	12.7-22.4	18.7	12. 5-27.9	20.8	11.0-16.0	<.001
RDW_SD (fL)	33.2-66.0	43.8	34.5-56.6	43.0	37.7-60.8	43.6	36.1-55.6	42.7	32.8-62.8	46.6	37.0-54.0	.164
WBC (10^3/μL)	2.40-28.12	7.71	3.56-20.30	7.21	2.07-14.41	6.69	5.22-15.72	7.38	2.76-16.81	8.27	3.00-15.00	.358
LYMP (%)	3.8-63.2	29.7	5.1-55.3	41.7	11.3-63.3	28.9	9.1-55.6	28.1	14. 5-62.2	33.7	20.0-50.0	.175
LYMP# (10^3/μL)	0.5-7.5	2.0	0.5-5.1	2.4	1.2-5.6	2.4	1.0-6.3	2.3	0.7-5.1	2.3	1.00-3.70	.579
NEUT (%)	19.7-90.3	59.4	25.5-89.9	42.8	21.9-80.2	53.5	31.0-79.9	63.5	19.7-76.9	51.2	37.0-72.0	.131
NEUT# (10^3/μL)	0.53-11.34	4.59	1.11-8.30	3.16	0.83-11.55	3.82	1.93-9.57	3.97	0.62-9. 51	3. 43	1.50-7.00	.069
MONO (%)	1.7-29.1	11.1	4.8-18.0	11.4	7.1-28.2	12.9	7.1-15.2	11.2	5. 4-27.7	13.2	0.0-14.0	.128
MONO# (10^3/μL)	0.12-3.55	0.8	0.38-2.15	0.7	0.41-1.88	1.0	0.57-1.27	0.9	0.19-3.45	0.9	0.00-0.70	.359
EOS (%)	0.0-12.5	0.2	0.0-10.3	0.8	0.0-6.1	0.2	0.0-1.6	0.2	0.0-18.6	0.4	0.0-6.0	<.001
EOS# (10^3/μL)	0.00-0.63	0.01	0.00-0.61	0.06	0.00-0.42	0.03	0.00-1.29	0.01	0.01-0.18	0.05	0.00-0.40	.002
BASO (%)	0.0-3.3	0.1	0.0-0.5	0.1	0.0-1.9	0.1	0.0-0.7	0.1	0.0-3. 4	0.1	0.0-1.0	.081
BASO# (10^3/μL)	0.00-0.71	0.01	0.00-0.05	0.01	0.00-0.11	0.01	0.00-0.06	0.01	0.00-1.49	0.01	0.00-0.10	.101
PLT (10^3/μL)	21-614	124	60-766	296	51-604	198	85-508	171	6-812	301	150-400	.001
MPV (fL)	9.3-14.7	11.4	8.7-14.0	10.8	9.5-14.5	11.0	9.3-14.5	11.1	9. 4-13.7	11. 5	9.0-13.0	.426
PDW (fL)	9.0-21.9	13.4	8.9-18.4	12.2	9.9-21.9	13.0	9.9-21.9	13.1	9. 7-20. 4	12. 5	9.0-17.0	.438
PCT (%)	0.05-0.63	0.25	0.10-1.90	0.28	0.10-0.74	0.34	0.16-0.45	0.24	0.08-0.94	0.34	0.17-0.35	.306
P-LCR (%)	18.9-59.2	34.60	13.7-59.6	31.15	20.4-63.1	32.60	18.9-56.8	33.00	19.7-54.7	31.65	13.0-43.0	.668

**P*; analyzed by Kruskal-walis test, Mal- children infected with malaria parasites, Typ- children with salmonella infection, SCD- children with HbSS, Mal + Typ- children with malaria parasites and salmonella co-infection, Diarrhea-children with diarrheal diseases, Reference range; obtained from manufacturer's [Sysmex XS–500i (Symex Corporation, Kobe, Japan)] lower and upper cut-off values, L-below reference range, RBC-Red blood cell, HCT-Hematocrit, Hb-Hemoglobin, MCV-Mean corpuscular volume, MCH-Mean corpuscular hemoglobin, MCHC-Mean cell hemoglobin concentration, RDW_CV and RDW_SD-Red cell, distribution width, WBC-White blood cell, LYM(%)-Lymphocyte percentage, LYM#-Lymphocyte number, NEUT(%)-Neutrophil percentage, NEUT#-Neutrophil number, MONO(%)-Monocyte percentage, MONO#-Monocyte number, EOS (%)-Eosinophil percentage, EOS#-Eosinophil number, BASO(%)-Basophil percentage, BASO#-Basophil number, PLT- Platelets, MPV-Mean platelet volume. PDW-Platelet distribution width, PCT-Procalcitonin and P-LCR-Platelet larger cell ratio.

eosinophil differential counts, [EOS (%) and EOS#], were significantly higher in children with typhoid infection than in other disease groups (Table 3). Significantly lower levels of MCH were found in children with SCD while higher platelet counts were seen in children with diarrhea (Table 3). Relative to mono-infections of malaria and typhoid, intermediate levels of most red cell parameters and PLT counts were observed in children with malaria-typhoid co-infection (Table 3).

4 | DISCUSSION

Many diseases in humans have similar clinical symptoms, and for those of infectious origin, laboratory diagnosis is usually the key in unraveling the disease causing organism. Febrile illness is one of the major causes of child morbidities and mortalities[1] in developing countries and a common symptom in children who report for health care delivery. The evaluation of fever in children is therefore a key clinical diagnosis of serious and life threatening disease in children. The independence of fever to each disease category in this study adds to the numerous reports that fever in children has different etiologies. In this study, vomiting and loss of appetite were respectively most prevalent in children with malaria and diarrheal diseases, however, most of the disease symptoms were overlapping amongst the various disease categories, which is in consonance with the study[1] that has reported these symptoms as common in children with febrile illness. Malaria was expectedly the most prevalent single infection reported in this study, because studies have shown that there is nearly an all year transmission in the Tamale metropolis.[17] However, diarrhea and typhoid fever being the next most prevalent single infections were more common amongst children aged ≤5 year. Young children within this age range are considered as more susceptible to these infections by reason of their continual exposure to their surroundings. They often tend to play, feed and have more contact with dirty surroundings, increasing their chances of contracting gastrointestinal and other infections. More so, the prevailing warm and humid environmental conditions during most part of the year in the metropolis concomitant with prevalent insanitary practices by many inhabitants promote the growth and survival of a wide range of pathogens, including bacteria, viruses, and protozoa that cause childhood diarrheal diseases and typhoid fever. Our finding showed that all children with positive sickling status were genotypically HbSS and for that matter had sickle cell disease. This may lend credence to the fear of a possible trait fixation and may also suggest that selection of the sickle cell gene (HbS) is high in Tamale. What is more disturbing is the poor attitude by the public towards SCD,[18] suggesting the need for intensive education on all fronts so as to reduce the incidence and minimize the burden of SCD among the Ghanaian populace. The study, however, reports a prevalence of 3.7% of malaria/typhoid co-infection amongst children in Ghana. To the best of our knowledge, this is the first time this has been reported in children in Ghana, but the prevalence compares to that of 3.9% reported among adults in a study conducted by Afoakwah et al[19] in the Sunyani and Kumasi metropolises of Ghana. In order to establish which hematological indices could be helpful in the differential diagnosis of the childhood illnesses, we examined critically the hematological profiles for the children under study. It was revealed that, red cell parameters (RBC count, Hb, MCV, MCH, and RDW_CV), platelet and eosinophil differential counts were different in all disease groups suggesting that blood components of children in Tamale may be defined by the type of infection or disease/illness. Malaria, typhoid, and SCD, were found to affect red blood cell parameters; reducing their counts, thus corroborating with previous studies implicating these diseases with anemia.[8,9,12,20-22] However, lowest platelet (PLT) count and a significant association of thrombocytopenia with children with malaria, distinguished malaria from the other childhood illnesses; and such an observation has been shown to be a common finding in adult malaria.[23,24] Lower MCH count was distinct for the children with SCD, which is substantiated by findings from other parts of the world.[25,26] A lower MCH is possibly due to the hemolytic tendencies conferred by the sickling of fragile RBCs during crisis without a concomitant rapid replacement with fully formed RBCs. However, we observed no distinct hematological indices among the children with typhoid, diarrhea, and malaria-typhoid co-infection. Comparison of the indices across the disease groups revealed significantly higher eosinophil count in children with typhoid. This observation agrees with the study which showed that enteric fever increases eosinophils in salmonella patients.[27] Also the comparison showed significantly higher platelet count in children with diarrheal disease. Even though such an observation is unknown, this may be attributed to such factors as the role of platelets in homeostasis, inflammation, immunity, tissue regeneration and other patho-physiological processes.[28] Although hematological indices cannot in entirety be used to diagnose diseases/defects, they could complement diagnostic tests, such as microscopy and serology in differential diagnosis and in probing for infections. Thus, the hematological indices identified in this current study may be useful in complementing these tests in the differential diagnosis of childhood diseases. We recommend a further study for possible hematological indices that might be distinct for other illnesses or other fever causing infectious pathogens common among children in Tamale. Also, a future study with larger sample size is recommended to substantiate the cut-off values of the hematological indices we have identified for the various diseases.

In summary, our results confirm that malaria is the most prevalent single febrile infection among childhood diseases in the Tamale metropolis of Ghana. This information should prompt the Ghana Health service to intensify the current strategies being employed to control malaria in the metropolis. Our findings also suggest that hematological indices, including Hb, MCV and PLT, or MCH may be useful indices that could incite further diagnostic tests for malaria or SCD among children in Ghana.

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