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RESEARCH ARTICLE

BLOOD INDICATORS AND PERIPHERAL BLOOD COUNTS FOR MALARIA PATIENTS IN AL-HODEIDAH CITY, YEMEN

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Abstract

Background and Aims: Malaria patients are particularly susceptible to anaemia, a prevalent health issue in developing nations. Human performance, growth, and development are negatively impacted by this condition, which can become more complex if comorbidity occurs in a holoendemic stratum with strong and persistent malaria parasite transmission, like the west coast region of Yemen. The purpose of the study was to ascertain the prevalence and severity of anaemia in malaria patients residing in a permanent malaria transmission area in Yemen's west coastal region. Changes in blood indicators and peripheral blood cell counts were also examined.

Subjects and Methods: This study included 250 newly diagnosed malaria patients from malaria control centres in Al-Hodeidah Governorate. The sixth version of the EpiInfo statistical software was used to collect and analyse blood parameters. The study's objectives and benefits were explained to the participants, and participation was entirely voluntary. The institution's ethics committee approved the study.

Results: The male patients accounted for 71.6% and the female patients were 28.4%, with the mean age of 28.8 years with an SD equal to 13.5 years, and ages ranged from 2 years to 58 years. Most of our patients were in the age group of 16-25 years (38%). The mean haemoglobin level in malaria patients was 11.5 mg/dl, and 14.4% of the patients were suffering from severe anaemia. Below-normal PCV in the patients was present in 23.6%; the mean RBC count was 4.5x1012/L, and a very low rate (3x1012/L) occurred in 7.2% of the patients. Leucopenia (< 4.5x10⁹/L) occurred in 28.4% of the patients, and neutropenia occurred in 14.4% of the patients.

Conclusions: Malaria, anaemia, leukopenia, and thrombocytopenia were clearly evident in this study and pose serious public health challenges among the coastal population of Yemen. This emphasises the necessity of uniform policies, initiatives, and actions to stop anaemia and malaria in this area.

Keywords: Al-Hodeidah Governorate, anemia, complete blood count, malaria, Yemen.

INTRODUCTION

Malaria is an infectious disease carried by mosquitoes that can affect vertebrates. Human malaria typically manifests as headaches, nausea, fever, and fatigue. In severe cases, it can cause jaundice, convulsions, coma, or even death. Symptoms usually occur ten to fifteen days after being bitten by an infected *Anopheles* mosquito. If they are not properly treated, people may have disease recurrences months later. When someone has recovered from an infection, reinfection usually causes less severe symptoms. This partial resistance disappears over months to years if the person is not regularly exposed to malaria[1,2].

P. ovale and *P. malariae* usually induce a milder form of malaria. Malaria is typically diagnosed by microscopic examination of blood on blood films or antigen-based quick diagnostic procedures[1]. Although methods for employing the polymerase chain reaction to identify the parasite's DNA have been developed,

their cost and complexity prohibit their widespread application in areas where malaria is common[3]. Adults who have malaria usually have headache, fatigue, chills, muscle soreness, abdominal pain, and fever. These symptoms usually occur in intense, intermittent episodes that last roughly six hours, after which there is a period of sweating and fever alleviation[4].

Infection with parasites belonging to the genus Plasmodium causes malaria. 2 Six *Plasmodium* species, *P. falciparum, P. malariae, P. ovalecurtisi, P. ovalewallikeri, P. vivax, and P. knowlesi*, cause malaria in humans.[5]*P. falciparum* is the most often found species (~75%) among those affected, followed by *P. vivax* (~20%)[3]. While *P. falciparum* has historically been the primary cause of death, new research indicates that *P. vivax* malaria is almost as frequently linked to potentially fatal illnesses as *P. falciparum* infection diagnoses. 6 Regardless of the presence of an illness, mass drug administration (MDA) entails giving medication to every member of the local community. [6.] According to a 2021 Cochrane review, there has been no discernible decrease in the incidence of malaria transmission with community administration of ivermectin, based on low-quality evidence[7].

Vaccines against malaria have been another research objective. In 1967, the first encouraging trials showing the possibility of a malaria vaccine were carried out by immunising mice with live, radiation-attenuated sporozoites. This gave the mice a considerable level of protection when they were later injected with normal, living sporozoites. Considerable progress has been made in creating comparable human immunisation programmes since the 1970s[8]. With the long-term objective of eliminating malaria, WHO and the malaria vaccine funders group set a goal in 2013 to produce vaccinations intended to stop the disease's spread[9]. In 2015, European regulators approved the first vaccination, known as RTS, S[10]. There are two malaria vaccines that are approved for usage as of 2023[11]. Maintaining surveillance will also be critical to preventing the resurgence of malaria in nations that have eradicated the illness[12]. Antimalarial drugs are used to treat malaria; which ones are used depends on the kind and severity of the illness[13]. Although fever-reducing drugs are frequently prescribed, it is unclear how they affect the final result[14,15]. In South-east Asia, malaria that was partially resistant to artemisinins first appeared in the 2000s (decade)[16,17]. According to WHO predictions, in 2021, there were 247 million cases of malaria worldwide, resulting in 619,000 deaths. [11]In Sub-Saharan Africa, where an estimated 125 million pregnant women are at risk of infection, maternal malaria is assumed to be the cause of up to 200,000 estimated child fatalities each year[18].

Anaemia is a serious and often fatal complication of malaria, particularly in children and pregnant women. It results from the massive destruction (haemolysis) of both infected and uninfected red blood cells and a decrease in their production in the bone marrow. This leads to low haemoglobin levels, causing severe weakness, organ damage, and the need for immediate treatment with antimalarial drugs, iron supplements, and sometimes blood transfusions[1,2,18]. In Yemen, several studies have been conducted on anaemia and blood pictures in adult heart failure patients[19], patients with acute lymphoblastic leukaemia undergoing chemotherapy[20], pregnant women[21], malnourished children under five years of age[22], pregnant women with pre-eclampsia[23], anaemia in HIV patients[24], severe anaemia associated with intestinal parasites[25,26] and anaemia in dialysis patients[27]. However, no studies have been conducted on anaemia in malaria patients in malaria-endemic areas. Therefore, the study aimed to determine the prevalence and severity of anaemia in patients suffering from malaria living in a permanent malaria transmission area in the west coastal region of Yemen. The study also focused on changes in peripheral blood cell counts and blood markers.

SUBJECTS AND METHODS

Study design

This descriptive cross-sectional study was based on a sample of 250 patients with newly diagnosed malaria in malaria centres in the Hodeida Governorate. The mass diagnosis was formed in line with standard laboratory methods, one of them being blood film, together with a prepared thin and thick blood smear to detect malaria. The observed blood markers through Sysmex included haemoglobin level, PCV, RBC counts, WBC counts, WBC differential counts, RBC index (MCV, MCH, and MCHC) and platelet counts over a period of one year from 1st January 2023 to 31st December 2023.

Data collection

A pre-made questionnaire was used to gather individual data, including test results, clinical information, and demographic information.

Statistical analysis

The data was analysed using the Epi Info statistical tool version 6 (CDC, Atlanta, USA). When the data was regularly distributed, the quantitative data was expressed as mean values or standard deviation (SD) using percentages to express the qualitative data.

Ethical consideration

The institution's ethical review committee approved data collection before it began. Prior to participation, the objectives and benefits of the study were explained to all participants and/or their guardians, and their verbal informed consent was acquired. Additionally, participants and their families were informed that participation was entirely voluntary and that they might withdraw without providing an explanation.

RESULTS

Table 1 shows the age and sex distribution of malaria patients in Al-Hodeidah city, Yemen, arriving at malaria centres in Al-Hodeidah city. The male patients' counts were 71.6%, and the female patients' were 28.4%. The mean age of our patients was 28.8 years, with an SD equal to 13.5 years, and ages ranged from 2 years to 58 years. Most of our patients were in the age group of 16-25 years (38%). Table 2 shows the haemoglobin level in malaria patients arriving at malaria centres in Al-Hodeidah city.

Table 1: Gender and age distribution of malaria patients (n=250).

Characters	N (%)
Gender	
Male	179 (71.6)
Female	71 (28.4)
Age groups	
< 16	24 (9.6)
16-25	95 (38)
26-35	71 (28.4)
> 36	60 (24)
Mean age	28.8 years
SD	13.5 years
Median	26 years
Mode	23 years
Min-Max	2 years-58 years

Table 2: HGB level of malaria patients.

HGB (mg/dL)	N (%)
< 9	36 (14.4)
9-11	77 (30.9)
12-14	95 (38)
> 14	42 (16.8)
Mean	11.5
SD	2.3
Median	11.4
Mode	15
Min-Max	7-15

The normal Hb level for children is 11.9 to 15 g/dl; that for male and females.

The mean haemoglobin level in malaria patients was 11.5 mg/dL, the standard deviation level was 2.3 mg/dL and the haemoglobin level ranged from 7 to 15 mg/dL; 14.4% of the patients were suffering from severe anaemia and 30.9% from mild anaemia. Table 3 shows the PCV level of malaria patients in Al-Hodeidah city, Yemen. Below normal PCV in the patients was present in 23.6%; the PCV level reached 30-40 in 47.6% of patients, and 28.8% of the patients had a > 40 level.

Table 3: PCV level of malaria patients.

PCV (%)	N (%)
< 30	59 (23.6)
30-40	119 (47.6)
> 40	72 (28.8)
Mean	35.7
SD	7.1
Median	35.6
Mode	28
Min-Max	24-53

Normal levels of PCV in children range from 30-44%.

Table 4 shows the number of red blood cells in patients with malaria in Al-Hodeidah city, Yemen (cell x 106/µl). The mean RBC count was 4.5 cells × 106/µl. A very low rate (<3 cells x 106/µl) occurred in 7.2% of the patients. The result showed that only 26.2% of the patients had a normal value. Table 5 shows the white blood cell count in malaria patients (cell x 109/L). Leucopenia (< 4.5 cell x 109/L) occurred in 28.4% of the patients. The mean white blood cell count was 7.8 cells x 109/L with an SD of 8.2 and ranged from 2.5 to 15 cells x 109/L. Table 6 shows that neutropenia occurred in 14.4% of the malarial patients.

Table 4: Red blood cell counts of malaria patients.

RBC (cell x 10^{12}/L)	N (%)
< 3.0	18 (7.2)
3-5	166 (66.4)
> 5.0	66 (26.2)
Mean	4.5
SD	0.93
Median	4.6
Mode	3.9
Min-Max	2.2-7

A normal RBC count would be around: children 4.0 to 5.5 x 10^{12}/L.

Table 5: White blood cell counts of malaria patients.

WBC (cell x 10^{9}/L)	N (%)
< 4.5	71 (28.4)
4.5-11	155 (62)
> 11	24 (9.6)
Mean	7.8
SD	8.2
Median	5.6
Mode	3.5
Min-Max	2.5-15

A normal WBC count would be around: children (4.5 to 11.0 x 10^{9}/L).

The mean neutrophil percentage was 61.9% with an SD of 19 and ranged from 14 to 93%. Table 7 shows the mean lymphocyte percentage was 30.1% with an SD of 17.2 and ranged from 5 to 75%. Table 8 shows the mean monocyte percentage was 5.5% with an SD of 2.7 and ranged from 0 to 10%.

Table 6: Neutrophils counts of malaria patients.

Neutrophils (%)	N (%)
< 40	36 (14.4)
40-70	65 (26.1)
≥ 71	149 (59.6)
Mean	61.9
SD	19
Median	62
Mode	61
Min-Max	14-93

Normal range for neutrophils: 40-70%.

Table 7: Lymphocyte counts of malaria patients.

Lymphocytes (%)	N (%)
< 20	66 (26.4)
20 - 40	125 (49.8)
≥ 41	59 (23.8)
Mean	30.1
SD	17.2
Median	27.5
Mode	30
Min - Max	5 - 75

Normal range for lymphocytes: 20-40%.

Table 9 shows the mean eosinophil percentage was 2.2% with an SD of 1.8 and ranged from 0 to 7%. Table 10 shows the mean basophil percentage was 1.0% with an SD of 0.7 and ranged from 0 to 7%. Table 11 shows the MCV level in malaria patients. Below 80 fl (femtoliters) occurred in 47.6% of our patients who have microcytic anaemia. The mean MCV was 78.3 fl with SD equal to 11.8 fl, and the MCV ranged from 21.6 fl to 95 fl.

Table 8: Monocyte counts of malaria patients.

Monocyte (%)	N (%)
< 2	12 (4.8)
2-8	196 (78.4)
> 8	42 (16.8)
Mean	5.5
SD	2.7
Median	5
Mode	3
Min-Max	0-10

Normal range for monocytes: 2-8%.

Table 9: Eosinophilcounts of malaria patients.

Eosinophil (%)	N (%)
< 1	23 (9.2)
1-6	215 (86)
> 6	12 (4.8)
Mean	2.2
SD	1.8
Median	2
Mode	2
Min-Max	0-7

Normal range for eosinophils: 1-6%.

Table 10: Basophilecounts of malaria patients.

Basophile (%)	N (%)
< 1	235 (94)
1-3	13 (5.2)
> 3	2 (0.8)
Mean	1
SD	0.7
Median	0.3
Mode	0.0
Min-Max	0-7

Normal ranges for basophile: 0 to 300 basophils per microliter of blood.

Table 12 shows the MCH was 27.5 picograms per cell with SD equal to 9.7, and the MCH ranged from 17 to 87. More than 59% of the patients had less than 27 picograms per cell, indicating iron deficiency anaemia, while 7% had >31 picograms per cell, indicating anaemia due to low levels of folic acid or vitamin B12.

Table 11: MCV level of malaria patients in Al-Hodeidah Governorate, Yemen

MCV (femtoleter)	N (%)
< 80	119 (47.6)
80-84	72 (28.6)
85-89	36 (14.3)
> 89	23 (9.2)
Mean	78.3
SD	11.8
Median	80
Mode	83
Min-Max	21.6-95

MCV (Mean corpuscular volume/femtoleter) below 80 fL (femtoliters) typically indicates microcytic anemia, while an MCV above 100 fL may suggest macrocytic anemia.

Table 13 shows the mean MCHC was 32.1 g/dL with SD equal to 2.1, and the MCHC ranged from 28 to 36.7. The platelet counts of malaria patients are displayed in Table 14; the platelet counts of our patients ranged from 35 to 553 cells per microlitre (mL), with a mean of 206.6 cells per mL and an SD of 125 cells per mL. Thrombocytopenia occurred in 42.8% of our patients. Table 15 shows the number of malaria recurrences during the past year. Malaria infection occurred for the first time in 35.6% of patients; 28.7% of patients had a second infection, 26.2% had a third infection, and 9.2% had a fourth infection.

Table 12: MCH level of malaria patients.

MCH (picograms per cell)	N (%)
< 27	149 (59.6)
27-31	83 (33.3)
> 31	18 (7.2)
Mean	27.5
SD	9.7
Median	26.5
Mode	26
Min-Max	17-87

The normal MCH (mean corpuscular hemoglobin) range is 27 to 31 picograms per red blood cell. Values outside this range may point to an underlying condition, most commonly a form of anemia: low MCH often suggests iron-deficiency anemia, while high MCH can indicate anemia due to deficiencies in folic acid or vitamin B12.

DISCUSSION

This study characterises the demographic and comprehensive haematological profile of malaria patients attending malaria centres in Al-Hodeidah city, Yemen. The pronounced male predominance (71.6%) and concentration of cases among young adults aged 16-25 years (38%) reflect well-documented exposure patterns in endemic regions. This sex disparity is consistent with findings from Yemen and similar settings, where males engage more frequently in outdoor occupations such as agriculture and fishing during peak Anopheles biting hours, thereby increasing infection risk[28,29]. Studies from Yemen and similar endemic areas consistently report higher malaria prevalence among males due to occupational and behavioural factors[30].

Table 13: MCHC level of malaria patients.

MCHC (g/dl)	N (%)
< 32	83 (33.2)
32-33.9	120 (48)
> 33.9	47 (18.8)
Mean	32.1
SD	2.1
Median	32
Mode	32
Min-Max	28-36.7

A normal MCHC (mean corpuscular hemoglobin concentration) typically ranges from 32-36 g/dL (320-360 g/L), though reference values may differ slightly between laboratories. Results outside this range can suggest anemia.

The mean age of 28.8±13.5 years further supports the epidemiological transition observed in areas of moderate endemicity, where repeated exposure has not yet conferred complete immunity, shifting the burden towards older children and young adults rather than preschool children as seen in holoendemic regions. Males in Yemen are more likely to engage in outdoor occupations (farming, fishing, and daily labour) that increase exposure to Anopheles mosquito bites, particularly during evening and night hours when vector activity peaks[11]. This demographic profile has

significant socioeconomic implications, as malaria-related morbidity in the economically active population can exacerbate poverty and hinder development in already vulnerable communities.

Table 14: Platelets counts of malaria patients.

Platelets (Cell x10^3/dl)	N (%)
< 150	107 (42.8)
150-450	135 (54.2)
> 450	8 (3)
Mean	206.6
SD	125
Median	163.5
Mode	86
Min-Max	35-553

A normal platelet count ranges from 150,000 to 450,000 platelets per microliter of blood. Having more than 450,000 platelets is a condition called thrombocytosis; having less than 150,000 is known as thrombocytopenia.

Table 15: Number of patients with malaria infections.

Malaria infections	N (%)
First time infected	89 (35.6)
Second infection	72 (28.7)
Third infections	66 (26.2)
Fourth infection	23 (9.2)
Mean	1.1
SD	1.08
Median	1
Mode	0
Min-Max	0-3

The haematological findings demonstrate a substantial anaemia burden, with a mean haemoglobin of 11.5±2.3 g/dL and 45.3% of patients exhibiting mild or severe anaemia. This aligns with the multifactorial patho-physiology of malarial anaemia, involving parasite-mediated hemolysis, immune destruction of uninfected erythrocytes, bone marrow suppression, and nutritional deficiencies[31,32]. The microcytic pattern observed in 47.6% of patients (MCV <80 fL) and low MCH in 59% suggests concomitant iron deficiency, which is highly prevalent in Yemen due to dietary limitations and chronic infections[33,34].

The correlation between low RBC counts (only 26.2% normal) and reduced PCV further confirms malaria's profound impact on erythropoiesis. These findings underscore the necessity of integrating anaemia screening and nutritional assessment into routine malaria case management, particularly in resource-limited settings where severe anaemia carries high mortality risk[35,36]. Leukopenia was observed in 28.4% of patients, with neutropenia in 14.4%, consistent with malaria-associated bone marrow suppression and peripheral sequestration of leukocytes[26]. The mean total WBC count of 7.8±8.2x10^9/L showed wide variability, reflecting the heterogeneous immune response to infection. Lymphocyte percentages (mean 30.1%) were within expected ranges, while eosinophil and basophil counts remained low, as is typically reported in acute malaria, where these cell lines are not primarily involved in the anti-parasitic response[35].

These alterations in white cell dynamics may serve as adjunctive diagnostic markers in settings with limited parasitological confirmation capacity, though they lack specificity and must be interpreted alongside clinical and epidemiological context[37]. Thrombocytopenia occurred in 42.8% of patients, with a mean platelet count of 206.6±125 x 10^3/µL. This finding is highly consistent with malaria literature, where thrombo-cytopenia is recognised as one of the most frequent haematological abnormalities, resulting from platelet activation, consumption, and immune-mediated destruction[38]. Although rarely causing spontaneous bleeding in uncomplicated malaria, thrombocytopenia may serve as a useful supportive diagnostic indicator and warrants monitoring in severe cases where coagulopathy can develop[38]. The relatively preserved mean platelet count in this cohort suggests most presentations were uncomplicated, though the wide range (35-553x10^3/µL) indicates substantial individual variability requiring clinical correlation.

The high recurrence rate, with 64.4% of patients reporting at least one prior infection and 9.2% experiencing four infections within one year, highlights ongoing transmission and potential challenges in treatment efficacy or prevention adherence. This pattern is concerning in the Yemeni context, where conflict-related disruptions to health services, inconsistent vector control, and limited access to quality-assured antimalarials may contribute to repeated infections[38]. Recurrent malaria not only increases cumulative anaemia risk with a reduction in haemoglobin levels but also suggests possible gaps in community-level prevention strategies, emphasising the need for strengthened surveillance, prompt case management, and targeted vector control interventions[33,39].

Limitations of study

Studies of hematological parameters and peripheral blood counts in malaria patients in Hodeidah, Yemen, are severely constrained by the ongoing conflict, resulting in significant limitations on data accuracy, study scope, and methodology. Key limitations include a high incidence of co-infection with other acute febrile illnesses (such as dengue fever), which can affect hematological test results; the prevalence of hypoparasites, which may go undetected by standard diagnostic criteria; and reliance on cross-sectional study designs that do not allow for tracking patient outcomes over time.

CONCLUSIONS AND RECOMMENDATIONS

In Yemen's coastal regions, malaria, anaemia, leucopenia, and thrombocytopenia continue to be serious public health issues. In order to prevent malaria and anaemia in the local community, this highlights the necessity of implementing consistent policies, initia-tives, and actions. One of the major obstacles to malaria control and the progression of anaemia is delay in diagnosis. For malaria to be effectively controlled, new and improved diagnostics are crucial. As they have been for the previous century, the most accurate methods for diagnosing malaria today are labor-intensive and depend on highly skilled personnel analysing blood smears under microscopes. Drug resistance cannot be detected by such microscopic

analysis, which is time-consuming, inconsistent in quality, and challenging to apply in field settings with limited resources. For the purpose of controlling malaria and avoiding consequences like anaemia, it is crucial to fund research into the development of simple tests to identify the malaria parasite and identify its drug resistance pattern.

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AUTHOR'S CONTRIBUTIONS

Al-Thamari JAM: writing the original draft, methodology, investigation. **Al-Moyed KA:** writing the original draft, methodology, investigation. **Al-Nuzaili MA:** formal analysis, data curation, conceptualisation. **Al-Haddad AM:** writing, review and editing, methodology. **Al-Shamahy HA:** formal analysis, data curation. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The empirical data used to support the study's conclusions are available upon request from the corresponding author.

CONFLICT OF INTEREST

This study is not connected to any conflicts of interest.

REFERENCES

1. Caraballo H, King K. Emergency department management of mosquito-borne illness: Malaria, dengue, and West Nile virus .Emergency Medicine Practice 2014; 16 (5):1-23.
2. CDC-Clinical Guidance: Malaria diagnosis and treatment in the U.S. Malaria - CDC 2024. *https://www.cdc.gov/malaria/hcp/clinical-guidance/index.html*
3. Nadjm B, Behrens RH. Malaria: an update for physicians. Infectious Disease Clinics of North America 2012; 26 (2): 243-259. *https://doi.org/10.1016/j.idc.2012.03.010*
4. Despommier DD, Griffin DO, Gwadz RW, Hotez PJ, Knirsch CA. Parasitic Diseases (7 ed.). New York: Parasites without borders 2019;110-115. ISBN 10: 1097115909, ISBN 13: 9781097115907
5. Ashley EA, Pyae Phyo A, Woodrow CJ. Malaria. Lancet 2018; 391(10130):1608-1621. *https://doi.org/10.1016/S0140-6736(18)30324-6.*
6. Baird JK. Evidence and implications of mortality associated with acute *Plasmodium vivax* malaria. Clin Microbiol Reviews 2013; 26 (1): 36-57. *https://doi.org/10.1128/CMR.00074-12*
7. De Souza DK, Thomas R, Bradley J, *et al.* Ivermectin treatment in humans for reducing malaria transmission. Cochrane database of systematic reviews 2021; 6(6):CD013117. *https://doi.org/10.1002/14651858.CD013117.pub2*
8. Vanderberg JP. Reflections on early malaria vaccine studies, the first successful human malaria vaccination, and beyond. Vaccine 2009; 27(1):2-9. *https://doi.org/10.1016/j.vaccine.2008.10.028*
9. WHO, World malaria report 2013. *https://www.who.int/publications/i/item/9789241564694*
10. Walshe DP, Garner P, Adeel AA, *et al.* Larvivorous fish for preventing malaria transmission. Cochrane Database Syst Rev 2017; 12(12):CD008090. *https://doi.org/10.1002/14651858.CD008090.pub3*
11. World Health Organization. World malaria report 2023. Geneva: WHO; 2023.
12. Mendis K. Eliminating malaria should not be the end of vigilance. Nature 2019; 573(7772):7. *https://doi.org/10.1038/d41586-019-02598-1*
13. Hanboonkunupakarn B, White NJ. Advances and roadblocks in the treatment of malaria. British J Clin Pharmacol 2022; 88(2):374-382. *https://doi.org/10.1111/bcp.14474*
14. Meremikwu MM, Donegan S, Sinclair D, *et al.* Intermittent preventive treatment for malaria in children living in areas with seasonal transmission. Cochrane Database of Systematic Reviews 2012; 2:CD003756. *https://doi.org/10.1002/14651858.CD003756.pub4*
15. Greenwood B, Mutabingwa T. Malaria in 2002. Nature 2002; 415(6872): 670-672. *https://doi.org/10.1038/415670a*
16. O'Brien C, Henrich PP, Passi N, Fidock DA. Recent clinical and molecular insights into emerging artemisinin resistance in *Plasmodium falciparum*. Curr Opin Infect Dis 2011; 24(6):570-577. *https://doi.org/10.1097/QCO.0b013e32834cd3ed*
17. Fairhurst RM, Nayyar GML, Breman JG, *et al.* Artemisinin-resistant malaria: research challenges, opportunities, and public health implications. The American J Trop Med Hygiene 2012; 87(2):231-241. *https://doi.org/10.4269/ajtmh.2012.12-0025*
18. Hartman TK, Rogerson SJ, Fischer PR. The impact of maternal malaria on newborns. Annals Trop Paed 2010; 30(4):271-282. *https://doi.org/10.1179/146532810X12858955921032*
19. Mosleh MN, Salem AS, Hajar A, *et al.* Prevalence of anaemia among adult heart failure patients in cardiac centres, Sana'a, Yemen. Sana'a University J Med Health Sci 2025; 19(6), 387-392. *https://doi.org/10.59628/jchm.v19i6.2168*
20. Al-Wajeeh AS, Al-Shamahy HA, Al-kibsi A, *et al.* Evaluation the oral health status for children with acute lymphoblastic leukemia receiving chemotherapy in Sana'a City, Yemen. Sana'a University J Med Health Sci 2025; 19(4): 253-265. *https://doi.org/10.59628/jchm.v19i4.1955*
21. Mukbel Ahmed Al-Qubati M, Abdulkader Al-Nuzaili, *et al.* Prevalence of anemia and associated factors among pregnant women attending Bajil Regional Hospital and public health centers in Bajil City, Yemen. Sana'a Univ J Med Health Sci 2026; 20(1): 449-455. *https://doi.org/10.59628/jchm.v20i1.2161*
22. Alqah JBR, Hajar A. The prevalence of anemia and its associated risk factors among malnourished children under five years age attending to Al-wahdah University Teaching Hospital in Thamar, Yemen. Sana'a University J Med Health Sci 2025; 19(6): 412-419. *https://doi.org/10.59628/jchm.v19i6.2055*
23. Al- Gunied ASAB, Salem AK, Al-Shamay HA, *et al.* Evaluation of the complete blood count parameters in pregnant women presenting with preeclampsia in AL-Gomhori Hospital Sana'a, Yemen. Sana'a University J Med Health Sci 2025; 19(2): 181-185. *https://doi.org/10.59628/jchm.v19i2.1636*
24. Al-Babeli IAA, Hajar MA, Salem, *et al.* Prevalence of pancytopenia among HIV patients attended to HIV centre in Sana'a City. Sana'a University J Med Health Sci 2025; 19(3): 210-215. *https://doi.org/10.59628/jchm.v19i3.1597*
25. Almagrami AA, Al-Hababi FHA, Al-Moyed KA, *et al.* Correlation between blood groups and severe anemia among anemia patients in Sana'a City, Yemen. J Hematol Blood Disord 2025;12(1): 103
26. Al-Halani AA, Edrees WH, Alrahabi LM, *et al.* Prevalence of intestinal parasites, malnutrition, anemia and their risk factors among orphaned children in Sana'a city, Yemen. Universal J Pharm Res 2023; 8 (2):1-8. *https://doi.org/10.22270/ujpr.v8i2.923.*
27. Mufadhal EA, Al-Showafi FK, Al-Shamahy HA, *et al.* The association between levels of hepcidin, iron status and micro-inflammation markers among haemodialysis. Universal J Pharm Res 2019; 4:5. *https://doi.org/10.22270/ujpr.v4i5.313.*

28. Al-Hamidhi S, Mahdy MA, Al-Hashami Z, *et al*. Genetic diversity of *Plasmodium falciparum* and distribution of drug resistance haplotypes in Yemen. Malar J 2013; 12:244. *https://doi.org/10.1186/1475-2875-12-244*
29. Abdul-Ghani R, Mahdy MA, Saif-Ali R, *et al*. Glucose-6-phosphate dehydrogenase deficiency among Yemeni children residing in malaria-endemic areas of Hodeidah Governorate and evaluation of a rapid diagnostic test for its detection. Malar J 2016; 15:327. *https://doi.org/10.1186/s12936-016-1372-9*
30. Workineh L, Lakew M, Dires S, *et al*. Prevalence of malaria and associated factors among children attending health institutions at South Gondar Zone, Northwest Ethiopia: A cross-sectional study. Sage Open Pediatrics 2021; 8(5): 2333794X2110591. *https://doi.org/10.1177/2333794X211059107*
31. Ghosh K, Ghosh K. Pathogenesis of anemia in malaria: A concise review. Parasitol Res 2007; 101(6):1463-1439. *https://doi.org/10.1007/s00436-007-0742-1*
32. White NJ. Anaemia and malaria. Malar J 2018; 17(1):371. *https://doi.org/10.1186/s12936-018-2509-9*
33. Kolarš B, Mijatović Jovin V, Živanović N, *et al*. Iron deficiency and iron deficiency anemia: A comprehensive overview of established and emerging concepts. Pharmaceuticals (Basel) 2025; 18(8):1104. *https://doi.org/10.3390/ph18081104*
34. Grewal US, Rastogi P, Ayyappan S (2024). Anemia of inflammation. Sokol L, Zhang L (eds) non-neoplastic hematologic disorders. Springer Cham. *https://doi.org/10.1007/978-3-031-62373-8_9*
35. Al-Mekhlafi AM, Al-Mekhlafi HM, Mahdy MA, *et al*. Human malaria in the highlands of Yemen. Ann Trop Med Parasitol 2011; 105(3):187-195. *https://doi.org/10.1179/136485911X12987676649421*
36. Azazy AA, Alhawery AJ, Abdul-Ghani R, *et al*. Evaluation of rapid PfHRP-2/pLDH-based tests in diagnosing microscopy-confirmed falciparum malaria in Hodeidah Governorate, Yemen. Acta Trop 2018; 178:252-257. *https://doi.org/10.1016/j.actatropica.2017.12.006*
37. Atroosh WM, Al-Mekhlafi HM, Al-Jasari A, *et al*. Different patterns of PFCRT and PFMDR1 polymorphism in *Plasmodium falciparum* isolates from Tehama region, Yemen. Peer J 2016; 4:e2191. *https://doi.org/10.7717/peerj.2191*
38. Al-Maktari MT, Bassiouny HK, Al-Hamd ZS, *et al*. Malaria status in Al-Hodeidah Governorate, Yemen: Malariometric parasitic survey and chloroquine resistance *P. falciparum* local strain. J Egypt Soc Parasitol 2003; 33(2):361-372.
39. Menendez C, Fleming AF, Alonso PL. Malaria-related anaemia. Parasitol Today 2000; 16(11):469-476. *https://doi.org/10.1016/S0169-4758(00)01774-9*