## Background
Malaria infection is common in the state of Odisha and is a common cause of childhood morbidity, with varied hematological consequences. This study was conducted to find out pattern of the hematological changes in children infected with malaria.

## Objectives
The changes in the blood in acute malaria are previously described. The present study was undertaken to examine and compare the incidence and severity of changes in blood-parameters in children suffering from two most common types Pl. falciparum and Pl. vivax malaria and to find out which blood changes are most important predictors of malaria infection in this study area of central Odisha.

## Methods
This was an observational study included eighty one cases of acute malaria patients who attended Paediatric Medical Out patient Department of Sardar Vallabhbhai Patel Post Graduate Institute of Paediatrics (Sishu Bhawan), Cuttack, Odisha, during the period from September 2015 to August 2016. The diagnosis of malaria was confirmed by examining both thick and thin blood smears after being stained with Leishman’s stain. The blood slides were examined for malaria parasites by two independent pathologists and complete blood count (CBC) were performed using an automated coulter counter ‘Sysmex machine’.

## Results
From examination of blood samples of 81 children who were confirmed malaria cases it was found that 80% of patients had anaemia, 59% thrombocytopenia and 51% neutrophilia. The other overall finding were lymphopenia (14%), leucopenia (12%), eosinophilia (12%) and monocytosis (4%). There was no significant difference in incidence of anaemia in Pl. falciparum (81%) and Pl. vivax (78%) p value > 0.05, whereas the incidence of thrombocytopenia was more in Pl falciparum (62%) than that of Pl vivax (33%). Moreover lymphopenia was found in 44% in Pl vivax in comparison to 10% in Pl falciparum malaria, p value < 0.04. Eosinophil, basophil and monocyte count showed no significant changes in two most common falciparum and vivax malaria.

## Conclusions
Pl. falciparum and Pl. vivax malaria infection can cause significant hematological changes in children with more commonly of anaemia, thrombocytopenia, lymphopenia and frequently neutrophilia which may be considered as corroboration predictors of malaria infection. Though not specific, when used in combination with other clinical and microscopic findings, these parameters could improve malaria diagnosis in children.

## Introduction
Malaria is a serious mosquito-borne disease which is one of the most prevalent human infections in the world. It is a disease of tropical and sub-tropical countries mostly of Africa and Asia[1,2]. It continues to cause significant morbidity and mortality in India including the state of Odisha[3]. The hematological changes in malaria has been investigated as blood is the most easily obtainable diagnostic tissue. Changes in blood parameters are likely to be influenced by any disease process including malaria where hematological changes play important role in pathogenesis and therefore such changes may be predictors of diagnosis and complications of the disease[4,6].

## Objective
The aim of the study was to elucidate and assess the hematological changes that frequently occur in malaria infection in children in this locality of central Odisha.

## Methods
The present study was an observational study and was conducted in Sardar Vallabhbhai Patel Post Graduate Institute of Paediatrics (Sishu Bhawan), Cuttack, which is the largest tertiary care children hospital in the state of Odisha, and is an extended unit of SCB Medical College Hospital. Participants were all 81 children with confirmed diagnosis of malaria who attended the Outpatient Department of Sardar Vallabhbhai Patel Post Graduate Institute of Paediatrics (Sishu Bhawan), Cuttack, during the period September 2015 to August 2016. The parent/guardians of the study participants gave a written informed consent before being enrolled in to the study.

## Inclusion criteria
Patients of paediatric age (upto 14 years) both male and female who were having diagnosis of malaria as evidenced by positive blood smears for any malaria parasite (Pf, Pv or mixed), and whose parents agreed with written consent to participate in the study.

## Exclusion criteria
Children with clinical history and/or finding suggestive of other infections, bleeding disorder, thrombocytopenia, drug intake or conditions which might have contributed in blood changes and when there was unwillingness by parents to participate were excluded from the study.

A total of 81 children with microscopically confirmed malaria were investigated. Biodemographic information obtained include age, gender, detailed clinical history, duration of illness and history of treatment received. All the recruited subjects were investigated for microscopic examination of malaria parasite in blood smear using Leishman stain and complete blood count (CBC) were performed using an automated coulter counter ACT5 Diff Haematology Analyzer ‘YN-350 Sysmex machine’ as per company guideline following SOPs within 1 hour. Everyday quality control checks were performed and recorded; commercial controls were used in accordance with manufacturer’s recommendations.

The machine provided data on WBCs, RBCs, haemoglobin level, platelet counts, Mean platelet volume, red cell distribution width (RDW) and five part differentials and histograms. Haematological parameters (red blood cells, white blood cells, platelets, red cell distribution width, mean platelet volume and haemoglobin) of children suffering from Pl. falciparum and Pl. vivax were compared and analyzed. According to WHO criteria the thrombocytopenia was defined when total platelet count is below 100,000/cu mm of blood, whereas anaemia was defined as haemoglobin level <10g/dl for both male and female patients of paediatric age group. All other parameters were compared against normal reference range which are internationally accepted and mentioned in the manual of the machine. Data was analyzed by SAS Enterprise Guide 4. Statistical analysis included descriptive statistics, bivariate analysis i.e., t-test, chi-square and analysis of variance (ANOVA). A p value of < 0.05 was taken as significant for all statistical analysis.

The diagnosis of malaria was confirmed by examining both thick and thin blood smears after being stained with Leishman’s stain. The blood slides were examined for malaria parasites by two independent pathologists and species of malaria was detected from thin smear from which WBC differential was also done for all patients. All malaria positive smears were reviewed by another
hematologist/pathologist for confirmation, identification of species and review of smear for platelet counts and other hematological changes.

Results: In this study we found 81 children who were diagnosed of malaria infection, Pl.falciparum being the most common species comprising majority(84%) of malaria infection (Table-1). From examination of blood samples of 81 children who were confirmed malaria cases it was found that 80% of patients had anaemia,59% thrombocytopenia and 51% neutrophilia. The other overall finding were lymphopenia(14%), leukopenia(12%), eosinophilia (12%) and only(4%)monocytes (Table-2). There was no significant difference in incidence of anaemia in Pl.falciparum (81%) and in Pl.vivax (78%) p value>0.05 ,whereas the incidence of thrombocytopenia was more in Pl falciparum (62%) than that of Pl vivax(33%).Moreover lymphopenia was found in 44% in Pl vivax in comparision to 10% in Pl falciparum malaria, p value <0.04.Eosinophil, basophil and monocyte count showed no significant changes in two most common falciparum and vivax malaria.

Median values for Haemoglobin, Platelet count, RBC count, lymphocyte and eosinophils counts were significantly lower where as the Mean platelet volume (MPV), Monocyte and neutrophil counts were higher in the children suffering from malaria compared to the controls. There was no significant change noted in total WBC and RDW in children with malaria infection.

Table1: Showing species of malaria found in the study

<table>
<thead>
<tr>
<th>Total malaria cases</th>
<th>Pl.falciparum malaria</th>
<th>Pl.vivax malaria</th>
<th>Mixed malaria infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>68 (84%)</td>
<td>9 (11%)</td>
<td>4 (5%)</td>
</tr>
</tbody>
</table>

Table2: Showing various haematological changes in different species of malaria

<table>
<thead>
<tr>
<th>Haematological changes</th>
<th>Pl.falciparum malaria</th>
<th>Pl.vivax malaria</th>
<th>Mixed mal. infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaemia</td>
<td>35 (81%)</td>
<td>07 (78%)</td>
<td>03 (75%)</td>
</tr>
<tr>
<td>Thrombocytopenia</td>
<td>42 (62%)</td>
<td>03 (33%)</td>
<td>03 (75%)</td>
</tr>
<tr>
<td>Leukopenia</td>
<td>08 (12%)</td>
<td>01 (11%)</td>
<td>01 (25%)</td>
</tr>
<tr>
<td>Lymphopenia</td>
<td>07 (10%)</td>
<td>04 (44%)</td>
<td>00</td>
</tr>
<tr>
<td>Neutrophilia</td>
<td>37 (54%)</td>
<td>04 (44%)</td>
<td>00</td>
</tr>
<tr>
<td>Eosinophilia</td>
<td>09 (13%)</td>
<td>01 (11%)</td>
<td>00</td>
</tr>
<tr>
<td>Monocytosis</td>
<td>02 (3%)</td>
<td>01 (11%)</td>
<td>00</td>
</tr>
</tbody>
</table>

 Diagnostic values of haematological parameters in this study: Low haemoglobin, low platelet count and increased neutrophil count had fairly good predictors to diagnose malaria in children.

Conclusions: Presence of anaemia, thrombocytopenia in combination with and neutrophilia in children from endemic areas may be useful as supportive diagnostic criteria for malaria in situations where definitive microscopic or RDT may be non-available due to any reasons. Therefore, when used in adjunct to clinical and microscopy findings, changes in haematological parameters can significantly improve early malaria diagnosis thereby reducing morbidity and mortality in children.

References:
1. W.H.O malaria disease burden in South East Asia Region:23rd April 2010
13. Beale PJ, Cormack JD, Oldrey TB; Thrombocytopenia in malaria with immunoglobulin (IgM) changes. BMJ. 1972, 2 (5796): 345-349. 10.1136/bmj.2.5796.345.