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Clinicohematological and drug prescription details in children affected with malaria: A retrospective study from a tertiary hospital of an endemic region in India

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ABSTRACT

Background: Malaria is a life threatening plasmodial infection transmitted by infected female Anopheles mosquitoes. It infects mainly the reticulo-endothelial system and causes derangement in the hematological parameters. This study was undertaken to study the Clinicohematological and audit of drug prescription in children affected with malaria attending a tertiary care hospital at Mangalore in Karnataka state of India.
Materials and Methods: This was a retrospective study conducted in a tertiary care hospital among paediatric patients (<18 years of age) who were diagnosed with malaria during the study period. All the clinical details and other laboratory parameters were collected from the medical records and the lab parameters compared with control group, and statistical analysis was done. The mean, standard deviation was done for all the parameters and compared with control cases, using ANOVA /Kruskal Wallis test. The p value < 0.05 were considered as significant.
Results: A total of 290 children (males 182: females 108, 2:1) were included in the study, 204 (70.3%) patients had *P. vivax*, mixed malaria 71 (24.5%) and 15 (5.2%) had *P. falciparum*. The Majority of the patients (179, 61.72%) belonged to the age group of 11-16 years (Table 1). Among the 290 children diagnosed with malaria, all had fever. Vomiting (89, 30.7%) was second most common symptom. The haemoglobin, and total leucocyte count was reduced in all patients, whereas the Erythrocyte Sedimentation Rate (ESR) was significantly higher in the infected cases. There was significant thrombocytopenia seen mainly in falciparum group. The liver and renal functions were deranged in infected cases. Among the 204 vivax group of patients, chloroquine (187, 91.67%) was the most frequently administered drug. All patients with *P. falciparum* and mixed group were treated with Artemether. Anti-hypnozoites drug, i.e. Primaquine were administrated to all vivax and mixed malarial patients as per guidelines for 14 days.
Conclusions: The study area is a well document endemic region for vivax malaria and our results agreed to previous reports in this study with the paediatric age group. The audit of drug prescriptions suggests that the drugs prescribed were as per guidelines in majority of the children.

1. Introduction

Malaria is a parasitic infection caused by Plasmodium species, transmitted by the bite of an infected female

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Anopheles mosquito. Humans are infected by mainly four Plasmodium species i.e., *P. falciparum*, *P. vivax*, *P. malariae* and *P. ovale*.[1] Malaria is endemic in many parts of the world and reports suggest that 228 million cases were diagnosed worldwide in the year 2018.[2] In India, 0.4 million cases were reported in 2018, majority of cases were from states with forest, hilly and tribal areas like Odisha, Chattisgarh, Jharkhand, Madhya Pradesh, Maharashtra in the central part of India and Tripura, Meghalaya and Mizoram in the eastern part of the country.[3] The state of Karnataka, reported 8174 cases in 2018, of which 86% (7042) were from the district of Dakshina Kannada alone.[4]

Clinically, malaria is a preventable and curable disease, but can be life-threatening, if not diagnosed and treated on time. Most of the cases present with malarial paroxysm with typical high grade fever with chills and rigor, anemia and hepatosplenomegaly.[2] Complications like black water fever, cerebral malaria are commonly seen with *P. falciparum*, whereas relapse is common in *P. vivax due* to activation of hypnozoites in liver cells.[5,6]

Malaria is a serious disease in the pediatric age group. It is estimated that at a global level in the year 2018, 405,000 deaths were due to malaria and that 272,000 were in the most vulnerable population the children under the age of five.[2] In Sub - Saharan Africa alone, the burden of the *P. falciparium* infection in children is as high as 24 million according to the World Health Organization report.[2] The principal reason is that being intra-erythrocytic parasite, malaria is known to cause major derangement in hematological parameters mainly RBC, WBC and platelets.[5] Severe anemia, leukopenia and thrombocytopenia are very well documented in falciparum malaria.[6–10] Further, all major organs like the brain, liver and renal can be affected by malaria, patients with hepatorenal dysfunction have poor prognosis.[11]

A literature study suggests that the clinicohematological and treatment details of malaria caused by the different species have not been reported. Therefore, in this study, an attempt was made to understand the changes in laboratory parameters like haematology, hepato-renal among the paediatric malaria patients at a tertiary centre in Coastal Karnataka, India, which is documented to be an endemic region in India and the world.

2. Materials and Methods

The study was approved by the institutional ethics committee of Father Muller Charitable Institute (FMMCIEC/CCM/292/18). The inclusion criteria included all paediatric patients (<18 years of age) who were diagnosed with malaria during the study period (January 2015 to December 2018). The exclusion criteria were children infected with other acute infections (like dengue, leptospirosis, typhoid, tuberculosis and other bacterial, protozoal and viral infections), children suffering from cancers and blood disorders. Children having malaria and other co-infection were also not considered. By Diagnosis of malaria was established by staining a peripheral smear geimsa stain or by QBC test according to availability. All the other laboratory parameters were collected from the medical records of these children diagnosed of malaria. In addition to the haematological and biochemical data of age matched children who had come for nonspecific viral fevers, non-infectious dermatological issues were used as control to ascertain the quantitative difference between the controls verses the study group. The data collected were entered in Microsoft Excel and statistical analysis was done. The mean, standard deviation were done for all the parameters and compared with control cases, using ANOVA / Kruskal wallis test. The p value < 0.05 were considered as significant.

3. Results

A total of 290 children (males 182: females 108, 2:1) were diagnosed with malaria during the study period. Among them, 204 (70.3%) patients had *P. vivax*, followed by mixed malaria 71 (24.5%) and 15 (5.2%) had *P. falciparum* and these three categories were compared with control cases. The majority of the patients (179, 61.72%) belonged to the age group of 11-16 years (Table 1). There was no death reported among any children during the study period. Among the 290 children diagnosed with malaria, all had fever. Vomiting (89, 30.7%) was second most common symptom followed by headache (57, 19.7%) and convulsions (39, 13.6%) as shown in Table 1. Jaundice was observed only in 1 patient with mixed malaria.

Among the haematological parameters, the haemoglobin level was least in group with mixed malaria compared to others (Table 2). There was significant lower total leucocyte count in all categories compared to controls. Among the differential leucocyte counts, there was significant lower lymphocyte, eosinophil with higher monocyte counts among the malaria groups. There was significant difference in differential neutrophil count. The Erythrocyte Sedimentation Rate (ESR) was significantly higher in the infected cases. There was significant thrombocytopenia seen mainly in Falciparum group compared to mixed and vivax in decreasing order. The liver function was deranged significantly. The total bilirubin, and conjugated bilirubins were increased, significantly higher in mixed group.(Table 3) The liver enzymes were elevated, but reported to be higher in falciparum group. No significant difference was seen in AST / ALT ratio. The parameters of the renal system like urea were significantly higher in mixed malaria compared to other groups. The derangement in electrolytes seen was mainly hyponatremia, hypokalemia and hypochloremia. There was no significant difference in creatinine value in among the three infected groups.

Table 1: Distribution of symptoms among the children diagnosed with malaria.

	Symptoms	Vivax (N=204)		Falciparum (N=15)		Mixed (N=71)		Total (N=290)	
		Number	%	Number	%	Number	%	Number	%
Gender	Male	131	64.22	12	80.00	39	54.93	182	62.76
	Female	73	35.78	3	20.00	32	45.07	108	37.24
Age (in years)	01-05	38	18.63	4	26.67	16	22.54	58	20.00
	06-10	34	16.67	5	33.33	14	19.72	53	18.28
	11-16	132	64.71	6	40.00	41	57.75	179	61.72
Symptoms	Fever	204	100	15	100.00	71	100	290	100
	Vomiting	57	27.94	7	46.67	25	35.21	89	30.69
	Headache	43	21.08	4	26.67	10	14.08	57	19.66
	Convulsions	27	13.24	2	13.33	10	14.08	39	13.45
	Abdominal Pain	13	6.37	1	6.67	-	-	14	4.83
	Body ache	3	1.47	1	6.67	5	7.04	9	3.10
	Jaundice	0	0.00	0	0.00	1	1.41	1	0.34

Table 2: Comparison of blood cell parameters among the healthy and different malaria infections in children.

	Type	Mean ± Std. Dev	Post hoc analysis p with Bonferroni correction	Median (IQR)	ANOVA /Kruskal wallis test p value
Hb	Control	12.59±1.44		12.5(11.6-13.4)	0.0001 HS
	Vivax	11.25±1.9	0.0001	11.45(10.2-12.33)	
	Falciparum	12.04±2.54	1.000	11.8(10.7-14.4)	
	Mixed	10.9±2.35	0.0001	11.3(9.4-12.3)	
TC	Control	7903.22±2790.1		7800(5500-10200)	0.0001 HS
	Vivax	6362.84±3090.1	0.002	6000(4200-7600)	
	Falciparum	6557.14±4047.74	.883	5650(3725-7275)	
	Mixed	6764.18±3837.05	.180	5600(4200-8300)	
N	Control	61.87±10.52		63(54-70)	0.560 NS
	Vivax	62.89±15.93	1.000	65.5(53-75)	
	Falciparum	61.4±13.82	1.000	65(48-69)	
	Mixed	60.12±18.36	1.000	64(49-74)	
L	Control	33.17±9.77		32(26-40)	0.0001 HS
	Vivax	26.68±15.75	006	23(15-37)	
	Falciparum	28.13±15.17	1.000	22(18-39)	
	Mixed	29.49±18.18	.781	25.5(14.25-41.5)	
M	Control	2.22±1.18		2(1-3)	0.0001 HS
	Vivax	8.43±4.55	0.0001	9(6-12)	
	Falciparum	8.36±5.26	0.0001	10(3.75-12)	
	Mixed	9.07±4.21	0.0001	10(6-12)	
E	Control	2.86±2.19		2(1-5)	0.0001 HS
	Vivax	1.76±2.08	0.0001	1(1-2)	
	Falciparum	1.13±0.64	0.011	1(1-2)	
	Mixed	1.66±1.49	0.001	1(1-1)	

Hb- Heamoglobin(g%), TC - Total Leucocyte count (in cu.mm), N- Neutrophils (%), L- Lymphocytes (%), M- Monocytes (%), Eosinophils (%), HS- Highly significant, NS- Not significant.

Table 3: Comparison of hematological parameters among the healthy and different malarial infections in children

	Type	Mean±Std. Dev	Post hoc analysis p with Bonferroni correction	Median (IQR)	ANOVA /Kruskal wallis test p value
Platlets	Control	231125±80041.35		219000(163250-302500)	0.0001 HS
	Vivax	102197.6±70504.14	0.0001	92000(63750-121000)	
	Falciparum	93294.12±51191.75	0.0001	86000(59000-110000)	
	Mixed	97014.29±64925.49	0.0001	83500(56250-124750)	
ESR	Control	9.25±3.62		9(6-11)	0.0001 HS
	Vivax	23.71±19.57	0.0001	18(10-31)	
	Falciparum	19.63±13.62	.607	15.5(9.25-32)	
	Mixed	21.7±19.47	0.003	16.5(9-29)	
CRP	Control	3.51±2.5		2.76(1.07-5.41)	0.0001 HS
	Vivax	65.99±53.15	0.0001	53.53(27.18-88.45)	
	Falciparum	72.78±103.23	0.0001	28.57(10.11-179.67)	
	Mixed	58.57±58.34	0.0001	38.27(22.44-72.37)	
PCV	Control	40.05±4.02		39.45(36.78-43.03)	0.0001 HS
	Vivax	34.86±5.51	0.0001	35(31.5-38.2)	
	Falciparum	38.96±6.09	1.000	40.3(33.3-44.7)	
	Mixed	33.61±6.97	0.0001	35.6(29.08-37.9)	
MCV	Control	84.03±5.85		84.15(80.6-88.85)	0.0001 HS
	Vivax	79.41±6.48	0.0001	80(74.3-83.75)	
	Falciparum	78.49±6.36	.172	77.6(76-81.9)	
	Mixed	78.48±6.14	0.0001	79.95(73.95-81.98)	
MCH	Control	28.09±1.86		28.3(26.8-29.23)	0.001 HS
	Vivax	27.06±3	.203	26.6(25-28.08)	
	Falciparum	26.99±2.44	1.000	26.5(25-29.3)	
	Mixed	26.32±2.96	0.021	26.3(24.08-27.7)	

Platelets (/cu.mm), ESR- Erythrocyte sedimentation rate (mm/1st hour), CRP- C Reactive protein (mg%), PCV - Packed cell volume (%), MCV- Mean Corpuscular Volume (fL), MCH- Mean Corpuscular Heamoglbin (pg/cell) ,HS- Highly significant

When compared to controls, the acute phase protein, C reactive protein was significantly high in all the groups with, highest level was seen in falciparum group.(Table 4) In mixed malaria patients among the haematological parameters, it was observed that there was significant anaemia, monocytosis, reduced PCV, MCV, MCH, renal parameters like blood urea were increased and electrolytes were reduced.(Table 5) Among LFT, there was elevated bilirubin levels compared to other sub-group of patients. In Falciparum group, reduced eosinophil and platelets were observed among the haematological parameters and reduction in serum total protein, albumin, globulin and A/G ratio were observed. CRP was elevated significantly in this group. When compared with other groups, vivax malaria patients had significant leucocytosis, neutrophilia, lymphopenia and increased ESR.

Among the 204 Vivax group of patients, Chloroquine (187, 91.67%) was the most frequently administered drug, whereas Chloroquine artemether combination was prescribed in very few (13, 6.37%) patients (Table 6). Both Falciparum and mixed group were treated with Artemether. Anti-hypnozoites drug, ie Primaquine were administrated to all vivax and mixed malarial patients as per guidelines for 14 days.

4. Discussion

Malaria is a multisystem disorder, warranting hospitalization, appropriate antimalarial therapy and prevention of its complications.[12–15] *Plasmodium vivax* was the most common causative agent followed by mixed malaria. Isolated *Plasmodium falciparum* infection was the least common protozoa among cases. Similar, epidemiological trend was noted over a decade where *Plasmodium falciparum* accounted for 6.8 to 30.9% of all cases.[16] Similar observations were made in a large cross-sectional surveillance of 900 febrile patients at a city same as present study *P. vivax* and *P. falciparum* mixed

Table 4: Comparison of liver parameters among the healthy and different malarial infections in children

	Type	Mean±Std. Dev	Post hoc analysis with Bonferroni correction	Median (IQR)	ANOVA /Kruskal wallis test p value
AST	Control	20.28±6.06		19(15.25-25)	0.0001 HS
	Vivax	36.82±44.74	.203	24(19.25-33.75)	
	Falciparum	62.69±64.7	0.005	45(30-57)	
	Mixed	37.91±26.69	.343	30(19.5-50.5)	
ALT	Control	16.67±8.04		14(11-19)	0.0001 HS
	Vivax	26.21±27.39	.362	19(12-27)	
	Falciparum	45.00±33.56	0.007	37(24-54)	
	Mixed	33.11±33.89	0.036	20(14.5-43.5)	
AST/ALT	Control	1.43±0.74		1.2(0.74-1.98)	0.887 NS
	Vivax	1.44±0.56	1.000	1.31(1.07-1.8)	
	Falciparum	1.39±0.63	1.000	1.26(0.93-1.8)	
	Mixed	1.39±0.58	1.000	1.27(1.02-1.67)	
TB	Control	0.61±0.4		0.5(0.35-0.7)	0.0001 HS
	Vivax	1.27±1.41	0.050	1(0.71-1.32)	
	Falciparum	1.39±0.77	.357	1.3(0.82-1.58)	
	Mixed	1.87±2.13	0.002	0.95(0.53-2.16)	
CB	Control	0.22±0.12		0.2(0.1-0.3)	0.0001 HS
	Vivax	0.63±1.21	.402	0.4(0.29-0.55)	
	Falciparum	0.57±0.44	1.000	0.47(0.27-0.66)	
	Mixed	1.35±1.74	0.003	0.75(0.3-1.28)	
UB	Control	0.35±0.24		0.3(0.2-0.4)	0.0001 HS
	Vivax	0.71±0.42	0.002	0.63(0.43-0.83)	
	Falciparum	0.86±0.43	0.007	0.87(0.52-1.13)	
	Mixed	0.93±0.85	0.0001	0.5(0.37-1.36)	
Alb	Control	4.28±0.47		4.36(3.91-4.55)	0.001 HS
	Vivax	3.87±0.52	0.004	3.97(3.64-4.23)	
	Falciparum	3.78±0.53	0.049	4(3.5-4.29)	
	Mixed	3.8±0.66	0.015	3.92(3.25-4.32)	
Glob	Control	2.97±0.36		3(2.7-3.28)	0.015 sig
	Vivax	2.71±0.41	0.036	2.72(2.4-2.95)	
	Falciparum	2.85±0.4	1.000	2.78(2.47-3.3)	
	Mixed	2.74±0.57	.401	2.77(2.34-3.05)	
A/G	Control	1.46±0.27		1.4(1.3-1.58)	0.512 NS
	Vivax	1.46±0.28	1.000	1.46(1.27-1.68)	
	Falciparum	1.35±0.24	1.000	1.29(1.15-1.59)	
	Mixed	1.45±0.42	1.000	1.47(1.19-1.66)	

(AST -Serum Aspartate aminotransferase (IU/L),ALT- Serum Alanine Aminotransferase (IU/L), TB- Serum Total Bilirubin (mg%), CB-Serum Conjugated Bilirubin (mg%), UB -Serum Unconjugated Bilirubin (mg%), Alb -Blood Albumin (g%), Glob-Blood Globulin (g%), A/G - Albumin/ Globulin Ratio"), NS- Not significant, sig - significant, HS- Highly significant

Table 5: Comparison of renal parameters among the healthy and different malarial infections in children

	Type	Mean±Std. Dev	Post hoc analysis with Bonferroni correction	Median (IQR)	ANOVA /Kruskal wallis test p value
Creatine	Control	0.75±0.25		0.7(0.5-0.9)	0.198 NS
	Vivax	0.84±0.94	1.000	0.7(0.5-0.88)	
	Falciparum	0.85±0.23	1.000	0.82(0.73-0.93)	
	Mixed	1.05±1.32	.766	0.72(0.54-1.01)	
Urea	Control	16.44±4.14		17(13-19)	0.0001 HS
	Vivax	25.89±12.14	0.0001	23(19-30)	
	Falciparum	26.83±12.59	0.021	26(15.5-31.75)	
	Mixed	29.04±13.04	0.0001	28.5(20-36.75)	
Na	Control	139.04±1.73		139.5(138-140)	0.0001 HS
	Vivax	135.14±3.32	0.0001	135(133-137)	
	Falciparum	134.85±2.67	0.001	135(133.5-137)	
	Mixed	134.39±4.06	0.0001	134(133-137)	
K	Control	4.28±0.36		4.26(4.04-4.5)	0.003 HS
	Vivax	3.93±0.54	0.009	3.94(3.6-4.14)	
	Falciparum	4.1±0.56	1.000	4.04(3.66-4.35)	
	Mixed	3.91±0.51	0.032	3.87(3.5-4.4)	
Cl	Control	101.6±2.2		101.35(100.1-103.3)	0.0001 HS
	Vivax	96.83±10.3	0.04	97.7(94-101.3)	
	Falciparum	96.82±3.56	0.48	97.6(92.55-99.65)	
	Mixed	96.7±4.25	0.143	96.4(94.2-99.35)	

Creatinine - Serum Creatinine(mg%), urea- Blood Urea (mg%), Na- Serum Sodium (mEq/L), K -Serum Potassium (mEq/L), Cl- Serum Chloride (mEq/L), NS- Not significant, HS- Highly significant

Table 6: Antimalarial drugs administered to children diagnosed with malaria.

Medication administered	Vivax		Falciaprum		Mixed infection	
	Number	%	Number	%	Number	%
Chloroquine	187	91.67	-		-	
Artermether	4	1.96	15	100	71	100
Cq+ Ar	13	6.37	-		-	
Primaquine	204	100	15	100	71	100

infections were seen in 367 (81.7%), 67 (14.9%) and 15, respectively.[17] We have observed male preponderance with male: female ratio (2:1), similar findings have been reported in earlier reports.[11]

Fever was the most common symptom among all subtypes of malaria followed by vomiting (30.7%) and headache (20%). Fever was the single most important feature seen across all subtypes of malaria, which depends on the periodicity of rupture of schizonts.[17–19] Convulsions were reported in around 15% of our cases, which are in concordance (8-13%) with other studies.[18,19] Convulsions are common in children compared to adults. Usually, they herald the onset of cerebral malaria.[20] Convulsions occur due to febrile seizure, cerebral oedema, and hypoglycaemia or as a part of cerebral malaria.[20,21] Similarly, headache was seen in all forms of malaria ranging from 20-26% in present study. It is a common presenting complaint in malaria ranging from 18-66% of cases in different studies.[17,19,22] Cytokines, few anti-malarial drugs and post malaria neurologic syndrome are possible reasons for headache in malaria.[23] Though jaundice is one of the common findings in malaria, present study had only one case with clinical jaundice. This can be attributed to the fact that the district has one of the highest literacy rates and is a medical hub in the region. The people are very well aware of malaria and early referral and diagnosis is a possible explanation for the observation.

In pediatric falciparum malaria, the major complications include anemia, cerebral malaria and respiratory distress.[24] The complications in humans are attributed to its intra-erythrocytic phase of life cycle, leading to hematological changes like severe anemia, variations in leukocyte

count function and coagulopathy.[6] The most common hematological changes seen in malaria infected individuals are significantly low platelets, leucocytes, erythrocytes and hemoglobin levels.[6,25–28] Similarly, in our study population we have observed that the falciparum group showed significant low platelets, low haemoglobin in mixed malaria group (Table 2). In mixed malaria, we have seen with decreased levels of RBC, haemoglobin count, reduced packed cell volume, mean corpuscular volume and mean corpuscular haemoglobin. Our patients had leucocytosis in vivax malaria group which has been reported in other study,[25] in contrary to some studies demonstrating to leukopenia.[29] Other leucocyte changes observed were increased neutrophil and monocyte counts in vivax and mixed malaria group, respectively as explained in various studies.[25–28,30]

From a mechanistic view point, these derangements in the leucocytes are due to activation of bone marrow to produce and release more leucocytes and reduced lysis at the periphery.[25] Thrombocytopenia was noted among all the groups and it was significantly low compared to controls. Severe thrombocytopenia is the common complication especially in paediatric malaria cases[31]. Various studies across Indian subcontinent have documented this complication but need for platelet transfusion was extremely rare.[19,31,32] Though exact aetiology for this is not known it is attributed to both immunological and non-immunological destruction of platelets.[33] Demonstrations of *Plasmodium vivax* within platelets by electron microscopy have been postulated as direct lytic effect of the parasite on the platelets.[34] Oxidative stress induced thrombocyte destruction is also postulated aetiology.[35]

At molecular level, the production of cytokines like tumor necrosis factor (TNF) and interleukins is responsible for the derangement in the haematological parameters. These molecules in turn cause increased synthesis of C reactive protein (CRP), an acute phase inflammatory protein from liver, this explains the increased CRP in our study population.[36] However, CRP had a better correlation with infective state than ESR as it was significantly elevated in all groups. Though studies have noted strong linear trends regarding increasing CRP and severity of malaria no such conclusion could be drawn in present study.[37,38]

In malaria, the liver function is deranged with hyperbilirubinemia and increased aminotransferase enzymes.[11,39,40] The bilirubin levels were significantly increased in mixed malaria and increased liver enzymes in falciparum malaria. The suggested pathophysiological is the increased hemolysis of infected of RBC with cholestasis and hepatitis. Similarly, acute renal failure in malaria has been reported to be in as many of 60% cases.[41] Acute renal failure is may be seen in 80.9% and 11.7% in patients with *P. falciparum* and *P.vivax*, respectively.[42] On contrary, we have observed acute renal failure in mixed malaria group accompanied with hyponatremia, hypokalemia. No mortality was documented in present study, which can be attributed to early diagnosis & referral with less prevalence of HIV and malnourishment among children in our study population which are important contributing factors of mortality in malaria.

5. Conclusion

In conclusion, the change in clinico-laboratory parameters in various group of malaria infected paediatric population was studied. The most common derangement was seen in haemoglobin, platelets, PCV, MCH, blood urea, electrolytes and liver function parameters. These parameters can be used along with clinical features to consider malaria as differential diagnosis when a paediatric patients present with pyrexia of unknown origin, especially in malaria endemic area presents. The limitations of the study is that it's a retrospective study with no details of the general health status of the children, previous episodes of malaria infection which has effect on the various parameters studied.

6. Source of Funding

None.

7. Conflict of Interest

None.

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