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Genetic Disposition: Susceptibility of Human Blood Groups and Abo Analysis to Malaria and Typhoid Infections

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Abstract

Background: Malaria and typhoid have remained major infectious tropical diseases. Clinically, whenever there is severe malaria, cough is always an associating symptom owing to typhoid infection arising from poor hygiene in respect to drinking water and food. There is a strong association between human blood group and disease. Residual malaria transmission, effect of climate change on malaria vector composition, environmental management targeted at malaria breeding control as an intervention strategy are areas of interest to WHO in malaria control in Sub-saharan Africa. A body of data is been built on susceptibility of human blood groups to malaria, HIV and HBV and presently malaria and typhoid. If climate change warrants a change in composition of vectors and as well resistance to ACT therapy, the susceptibility or vulnerability of the human blood group is also called to question. The link between susceptibility of human blood group to malaria and typhoid has not been previously investigated. **Purpose**: The present study assesses the genetic disposition (susceptibility of human blood groups and abo analysis) to malaria and typhoid infections. **Patients and Methods**: One hundred (100) pa-

tients were screened for malaria and typhoid infections in a tertiary health facility—His glory hospital Lagos, Nigeria. Blood samples were collected by venu-puncture from 53 females and 47 males adults aged between 15 – 47 years, who were infected either singly or coinfected with malaria and typhoid. Microscopic detection of P. falciparum, widal serological technique for salmonella antibody presence and genotypic determination were all done using standard WHO methods. Human material or data were analyzed or performed in accordance with the declaration of Helsinki (2000). Ethical clearance was obtained from the ethic and research committee of the Ministry of Health via the Faculty of the Basic Medical Sciences, University of Calabar (Ethical Certificate number CRS/MOH/HRP/2023/396). **Results**: The results obtained expressed in percentage frequency show that genotype AA were more susceptible to typhoid and malaria infections compared to AS and SS, also blood group O was more susceptible to malaria and typhoid infection compared to blood groups A, AB and B, although, there is no significant difference between male and female gender, susceptibility to malaria infection, the female gender is more susceptible to typhoid than the male. The finding may be relevant to malaria susceptibility and genetics and thus provide baseline information on management of the scourge. **Conclusion**: We conclude that genotype AA and blood group 0^+ are more susceptible to malaria and typhoid infection in humans.

Keywords

Malaria, Plasmodium Falciparium, Genotype, Genetig Disposition

1. Introduction

Malaria is caused by obligate intracellular parasites, which lives in host erythrocyte and remodel these cells to provide optimally for their own needs. It is a major public health problem in tropical areas and it is estimated that malaria is responsible for 1 to 3 million deaths and 300 to 500 million infections annually [1]. Malaria remains the most complex and overwhelming health problem, facing humanity in vast majority of tropical and subtropical regions of the world with 300 to 500 million cases and 2 to 3 million death per year [2]. About 90% of all malaria deaths in the world today occur in sub-Saharan Africa and this is because the majority of infections are caused by *Plasmodium falciparum,* the most dangerous of the four human malaria parasites accounting for an estimated 1.4 to 2.6 million deaths per year in this region and which is responsible for the main endemic status of the region [3].

Besides, *Plasmodium falciparum* malaria has been a major cause of mortality and morbidity, particularly in endemic areas of sub-Saharan Africa [4]. The disease aetiology is variable and is attributable to environmental factors, host genetics and parasite virulence [5]. Variations in severity of *P. falciparum* infections considered as different phenotypes include hyper or asymptomatic parasi-

taemia (proportion of red blood cells that are parasitized), severe malaria anaemia (SMA) and cerebral malaria (CM). Host genetic factors contribute to the variability of malaria phenotypes [6] and thus, should help to determine some of the mechanisms involved in susceptibility to *P. falciparum* infection.

Typhoid fever is a bacterial infection due to *Salmonella typhi*. *Salmonella's* genus is Gram-negative, motile, non-sporing, non-capsule bacilli which exist in nature primarily as parasites of the intestinal tract of man and other animals. *Salmonella typhi* and the *paratyphoid* bacilli are found only in the intestinal tract of men for whom they frequently cause invasive disease that causes symptoms which may vary from mild to severe and usually begin six to thirty days after exposure with gradual onset of a high fever several days [7]. Weakness, abdominal pain, constipation and headaches are the commonest symptoms. Some people develop a skin rash with rose-coloured spots. Without treatment, symptoms may last for weeks or months. Other people may carry the bacterium without symptoms; however, they are still able to spread the disease to others [8].

Typhoid and malaria fever are two leading febrile illness affecting humans, especially in sub-Saharan Africa. They remain the disease of major public health importance and the cause of morbidity and mortality. Both diseases are common in many countries of the world where poor sanitary habits, poverty and ignorance exist.

The blood group is the classification of blood-based on the presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs). These antigens may be proteins, carbohydrates, glycoproteins or glycolipids, depending on the blood group system. The ABO blood group system places blood into four groups; blood group A with genotype 1^A 1^A or 1^A 1^O, blood group B with genotype 1^B 1^B or 1^B 1^O, blood group AB with genotype 1A 1B and blood group O with genotype 1^O 1^O. Genotypes are hereditary instructions that code for specific function in the body. Genotype simply refers to hemoglobin gene constituents [9].

The link between genetic disposition and disease is an evolving one. Malaria is both intra-erythrocytic (parasiteamic) and exoerythrocytic (malaria aparasitemia) and in the latter case, parasite may be sequested in deep tissues. Although, the link between the heamoglobin type or ABO has been reported previously [10] [11] [12], the susceptibility of human blood group to HIV and HBV infections was only reported recently by [13] and to extend the frontier of research therein, the susceptibility of human blood group to malaria and typhoid either singly or as in coinfection to both typhoid and malaria is the focus of the present study. Typhoid infection is most often associated with malaria. It is interesting to note that although the direct link between typhoid and genetic disposition has not been clearly established, yet cough and typhoid easily associated with malaria. The rational question is what is the link between malaria and typhoid? Normal gut flora protects against typhoid infection but malnutrition decreases or compromises normal gut flora and increases susceptibility to typhoid infection. For instance, malaria in children under five years results in malnutrition in re-

spect to vitamin A, Zn, iron, folate and other micronutrients. These in-turn upset the normal gut flora as the microbes may use these essential micronutrients now on short supply for normal growth and well-being. Therefore, malaria infection may decrease gut flora and lead to susceptibility to typhoid infection. There is no study on the genetic disposition (**susceptibility of human blood groups and ABO analysis) to malaria and typhoid infections** in humans and thus which blood grouping is most susceptible to malaria and typhoid infection is not known. This research will provide baseline information or empirical data on the genetic disposition (simple heamoglobin and ABO analysis which translate to susceptibility **of human blood groups and ABO analysis) to malaria and typhoid** of individuals (men and women of selected ages) to malaria and typhoid infection based on genetic constituent. The study therefore assessed the **genetic disposition (susceptibility of human blood groups and ABO analysis) to malaria and typhoid infections.**

2. Materials and Methods

Materials used for the study were of analytical grade and included: EDTA bottle, Test tube, Syringe, Blood samples, Slide, Physiological saline, Giemsa stain, Rocking tile (white), Applicator stick, Pasteur pipette, Test tube rack, Electrophoresis machine, Cellulose paper, Gloves, Centrifuge, Incubator, Microscope, Cotton-wool, Stop-watch, Antigen kit, Needle, Methylated spirit, Distilled water and Micro-pipette.

Study Location: The research study was carried out in the pathology laboratory of "His Glory Hospital, Coker, Lagos State, Nigeria" and was conducted from October 2022 to December 2023.

Ethical Clearance: The collection of samples analysis from diabetic patients and subsequent analysis of the data therefrom were done in accordance with the declaration of Helsinki (2000) and for the ethical clearance, ethical approval was obtained from the Ethics and Research Committee of the Cross River state, ministry of Health through the faculty of Basic Medical Sciences. The Ethical Certificate No. CRS/MOH/HRP/REC/2023/396.

Inclusion Criteria: Patients who had reported for clinic were screened for presence of malaria and typhoid. All malaria and typhoid-positive cases were selected during October 2022 to December 2022. The subjects were in the age range 15 - 47 of normal subjects.

Exclusion Criteria: Those suspected cases who were not suffering from malaria and typhoid but from illnesses were excluded from the study.

2.1. Collection of Blood Samples and Laboratory Investigation

Blood samples were collected from 53 female and 47 male patients by venipuncture technique using a sterile syringe and needle into a 5 ml screw cap sterile sample bottles in EDTA vials for malaria and thin blood film were made and samples were collected in plain vials for widal test. The samples were collected

only after the clinician had clerked the patient and from medical history suspected the presence of malaria and or typhoid.

2.2. Parasitological Examination

Blood smear stained with Leishmen stain and examined microscopically under oil immersion lens for the presence of malaria parasite (*P. falciparum* or *P. vivax*) within RBCs [14].

2.3. Microscopic Detection of *P. falciparum*

A thin film was prepared on a glass slide by placing a drop of blood on a clean and labeled glass slide. Another slide was inclined about angle 45˚ used to spread the blood to obtain ahead, body and a smooth tail (fishtail). The slide was air-dried on a staining rack, fixed with methanol for 3 minutes and allowed to air dry. Already prepared Giemsa stain was poured on the slide for about 30 minutes and rinsed. The slides were air-dried and viewed under the microscope using 100 x objectives (oil immersion) [15].

2.4. Widal Test

The widal test is a serological technique used to detect the presence of *Salmonella* antibodies in the patient's serum which was in turn obtained from 5 ml of the patient's venous blood collected into a plain bottle and the blood was spun at 3000 rev per min for 5 minutes so as to separate out the plasma. A dropper was used to carefully draw from the antigen kits and a drop was placed on each of the test card in pairs of four spots labeled O, OA, OB, OC and H, HA, HB, HC and a drop of serum was carefully added into the antigen respectively with the aid of Pasteur pipette and mixed together with the aid of applicator stick. The test card was rocked gently, the rate of reaction and agglutination was observed at an interval of 30 sec, 1 min, 2 mins and 5 mins.

Agglutination is a positive test which result indicates the presence of the corresponding antibody in the patient's serum [16] [17].

2.5. Genotypic Determination

Cells were washed two to three times in a test tube containing normal saline after which a drop of washed cells was placed on a tile. This is followed by the hemolysis of blood on the tile and the placement of AS and AA control using an applicator stick, after making sure that the buffer inside the electrophoresis tank covered the electrode, and the cellulose paper was placed on the tank, which is then covered and current switched on. Reading was recorded after 5 – 10 mins and the result for blood genotype was taken by studying the movement and separation of hemoglobin molecules [16] [17].

2.6. Statistical Analysis

The results were expressed as percentage frequency of occurrence of malaria and

typhoid. The choice of the percentage frequency was because the scale of measurement is nominal scale since it involves ABO blood grouping. The central purpose of variables measured on nominal scale is for identification and since nominal scale is the simplest and provides the lowest level of quantification of what is measured, either chi-square or percentages are appropriately applied to analyze the data. Blood group A, AB, O, and B are unordered variables and thus used for naming objects without comparative comparison, made therefore percentages were applied for the analysis.

3. Results

Table 1. Percentage of genotype susceptible to malaria.

			Genotype		Total
			AA	AS	
Malaria	Negative	Count	22	10	32
		% within Genotype	34.9%	27.0%	32.0%
		% of Total	22.0%	10.0%	32.0%
	Positive	Count	41	27	68
		% within Genotype	65.1%	73.0%	68.0%
		% of Total	41.0%	27.0%	68.0%
Total		Count	63	37	100
		% of Total	63.0%	37.0%	100.0%

Table 1 reveals the percentage of genotype that are susceptible to malaria (ie positive). From the table above, 68.0% of AA and AS genotype are susceptible to malaria while 32.0% are non-susceptible to malaria. Also, 41.0% of AA genotype are susceptible to malaria and 27.0% of AS genotype are susceptible to malaria. Within the genotype AA, there are 65.1% susceptibility to malaria and within the genotype AS, there are 73.0% susceptibility to malaria. This result indicates that AA genotype are more susceptible to malaria than AS.

Table 2. Percentage of genotype susceptible to typhoid.

			Genotype		Total
			AA	AS	
Typhoid	Negative	Count	31	23	54
		% within Genotype	49.2%	62.2%	54.0%
		% of Total	31.0%	23.0%	54.0%
	Positive	Count	32	14	46
		% within Genotype	50.8%	37.8%	46.0%
		% of Total	32.0%	14.0%	46.0%
Total		Count	63	37	100
		% of Total	63.0%	37.0%	100.0%

Table 2 shows the percentage of genotype that are susceptible to typhoid (ie positive) and also that non-susceptible to typhoid (ie negative), 32.0% of the total AA genotype are susceptible to typhoid and 14.0% of the total AS genotype are susceptible to typhoid. Within the genotypes: 50.8% of AA are susceptible to typhoid while 37.8% of AS are susceptible to typhoid. In general, AA genotype are more susceptible to typhoid than AS.

Table 3. Percentage of blood group susceptible to malaria.

			Blood Group				Total
			A+	AB+	B+	O+	
Malaria	Negative	Count	6	3	7	16	32
		% within Genotype	25.0%	37.5%	38.9%	32.0%	32.0%
		% of Total	6.0%	3.0%	7.0%	7.0%	32.0%
	Positive	Count	18	5	11	34	68
		% within Genotype	75.0%	62.5%	61.1%	68.0%	68.0%
		% of Total	18.0%	5.0%	11.0%	34.0%	68.0%
Total		Count	24	8	18	50	100
		% of Total	24.0%	8.0%	18.0%	50.0%	100.0%

Table 3 indicates the percentage of Blood Group that are susceptible to malaria (ie positive) and non-susceptible to malaria (ie negative). There are 18.0% of A+ blood group that are susceptible to malaria, 5.0% AB+ are susceptible to malaria, 11.0% B+ are susceptible to malaria and 34.0% O+ are susceptible to malaria. Within the blood group, we have 75.0% A+ blood group that are susceptible to malaria, 62.5% AB+ are susceptible to malaria, 61.1% B+ blood group are susceptible and 68.0% O+ are susceptible. In total, O+ blood group are more susceptible to malaria than other blood groups (A+, AB+, B+).

Table 4. Percentage of blood group susceptible to typhoid.

			Blood Group				Total
			A+	AB+	B+	O+	
Typhoid	Negative	Count	14	5	7	28	54
		% within Genotype	58.3%	62.5%	38.9%	56.0%	54.0%
		% of Total	14.0%	5.0%	7.0%	28.0%	54.0%
	Positive	Count	10	3	11	22	46
		% within Genotype	41.7%	37.5%	61.1%	44.0%	46.0%
		% of Total	10.0%	3.0%	11.0%	22.0%	46.0%
Total		Count	24	8	18	50	100
		% of Total	24.0%	8.0%	18.0%	50.0%	100.0%

In Table 4, the percentage of blood groups susceptible to typhoid (ie positive) and non-susceptible to typhoid is shown. Blood group A+ has 10% susceptibility to typhoid, blood group AB+ has 3.0% susceptibility to typhoid, blood group B+

has 11.0% susceptibility to typhoid and blood group O+ has 22.0% susceptibility to typhoid. The within-blood group susceptibility is also shown, for A+, there is 41.7% susceptibility to typhoid, AB+ has 37.5% susceptibility to typhoid, B+ has 61.1% susceptibility to typhoid and O+ has 46.0% susceptibility to typhoid. Susceptibility to typhoid are more prevalence in blood group O+.

Table 5. Percentage sex susceptible to malaria.

			Sex		Total
			(Female)	(Male)	
Malaria	Negative	Count	19	13	32
		% within Genotype	35.8%	27.7%	32.0%
		% of Total	19.0%	13.0%	32.0%
	Positive	Count	34	34	68
		% within Genotype	64.2%	72.3%	68.0%
		% of Total	34.0%	34.0%	68.0%
Total		Count	53	47	100
		% of Total	53.0%	47.0%	100.0%

Table 5 shows the percentage of sex susceptibility to malaria (i.e positive) and non-susceptibility to malaria (*i.e.* negative). Female has 34.0% susceptibility to malaria while male has 34.0% susceptibility to malaria. For the within sex, male has 72.3% susceptibility to malaria than the female which has 64.2% susceptibility to malaria. From the analysis, there is no significant difference between male and female susceptibility to malaria.

Table 6. Percentage sex susceptible to typhoid.

			Sex		Total
			(Female)	(Male)	
Typhoid	Negative	Count	29	25	54
		% within Genotype	54.7%	53.2%	54.0%
		% of Total	29.0%	25.0%	54.0%
	Positive	Count	24	22	46
		% within Genotype	45.3%	46.8%	46.0%
		% of Total	24.0%	22.0%	46.0%
Total		Count	53	47	100
		% within Sex	100.0%	100.0%	100.0%
		% of Total	53.0%	47.0%	100.0%

In Table 6, we have percentage of sex susceptibility to typhoid (ie positive) and non-susceptibility to typhoid (ie negative). There is 24.0% susceptibility to typhoid in female than male which has 22.0% susceptibility to typhoid. For the within sex, there are 46.8% susceptibility in typhoid in male while there are 45.3% susceptibility in typhoid for female. The total percent of susceptibility in typhoid is 46.0%.

4. Discussion

This study was conducted to ascertain the genetic disposition to malaria and typhoid infection. The result shows that those with genotype AA are more susceptible to malaria and typhoid infection compared to AS and SS. Also, blood group O+ was more susceptible to malaria and typhoid compared to blood groups A, AB and B.

This result agrees with previous reports of [18] [19] [20] [21]. The probable explanation for the observed result is that during the digestive process of malaria parasite, the toxic portion of the haemoglobin called haemin (Ferriprotoporphyrin) is converted to the non-toxic substance called haemozoin by the parasite enzyme (malarial haemopolymerase) thus enabling the parasite to survive, fueling the duplication and replication process. Haemoglobin S (HbS) unlike haemoglobin A (HbA) is deoxygenated, polymerized and poorly digested by the parasite. As a result, haemin accumulates thereby inhibiting the replication and survival of the parasite in HbS containing red blood cells. This is the major reason why the malaria parasite (*Plasmodium falciparum)* survives and thrives well in AA genotypes thereby contributing to the malaria susceptibility of people with the AA genotype [22] but not in the HbS.

It has also been shown that the rate-limiting enzyme haem oxygenase (HO-1), responsible for the catabolism of free haem in the body, plays an important modulating role in malaria and is also important in the pathophysiology of haemolytic diseases, such as sickle cell disease epistatic interactions between genetic disorders of haemoglobin (HbAs, thalassaemia, HbE etc) show evidence of heterozygote protection from malaria by sickle cell trait is removed if there is co-inheritance of alpha thalassaemmia [23].

It is not known why the ABO blood group O+ is susceptible to malaria and typhoid compared to other blood group A, AB and B. It may however be due to the composition of cell surface carbohydrates and other physiochemical attributes. Genotypic disposition that is susceptibility of human blood groups and ABO analysis to malaria and typhoid is topical because culex and Anopheles mosquito are vectors to filaria and malaria respectively. The present study may provide baseline information to address in part such questions as vector-related behaviour viz; what is the magnitude of residual malaria transmission in Nigeria? How does ongoing climate change affect malaria vector composition in the different ecological zones? Can environmental management be a new intervention strategy that can be exploited for malaria elimination? Are communities well involved environmental management practices targeted at control of malaria breeding [23].

Malaria parasite are both found in erythrocytic and non-erythrocytic compartments. The ABO blood grouping connected to the erythrocytic stage is influenced by the type of genetic makeup. That is to say, if the genetic composition of the vector changes due to climate change, invariably the ABO blood groupings that later interact with it may equally change. Some genetic traits offer some

form of protective mechanisms against malaria, for example, shape changes that prevent the malaria parasite—plasmodium falciparium from invading cells and inhibiting reproduction is one of them. Other factors include but not limited to; 1) abnormal sickle cell trait reducing susceptibility to infection to plasmodium faciparium. 2) HbAc that affects the shape and structure of RBCs protecting against P. falciparium infection. 3) Hereditary ovalocytosis which creates elliptically shaped RBC which interfere with parasites ability to adhere to, invade and grow within the cells. 4) Glucose-6-phosphate dehydrogenase deficiency which prevents growth of P.falciparium within the RBCs. 5) B-thalassemia which places individuals are risk of P. falciparium infection due to persistent of Hemoglobin F (fetal hemoglobin) which is not easily broken down by malaria parasites. 6) Duffy antigens and receptors present on RBCs can be highjacked by P.vivax to help it invade the cell. Many Africans are Duffy antigen-negative which probably protects them against vivax malaria.

The main causative agent of typhoid fever is salmonella typhi and salmonella paratyphi, both are members of the Enterobacteriaceae family. Salmonella is a genius [18] that has two species *Salmonella enterica serorar* and Enteriditis classified through extensive analysis by multiplex quantitative polymerase change reaction (PCF) [15]. Both Salmonella typhi and paratyphi (A, B, C) are *Salmonella enterica* serotypes. Non-typhoidal salmonella (NTS) is more typical in children and is mostly limited to gastroenteritis.

Salmonella is transmitted by the fecal-oral route through contaminated water, undercooked foods, and vomites of infected patients and is more common in areas with overcrowding, social chaos and poor sanitation. It is only transmitted from an infected person to another person, as humans are its only host. Major source of *Salmonella* are poultry, eggs and rardy turtles. In one study done on the distribution of *Salmonella* isolates by whole-genome sequencing in chicken slaughterhouse in China, 57% of samples were positive [9].

Normal flora of the gut is protective against the infection. The use of antibiotics such as streptomycin destroys the normal flora, which heightens its invasion. Malnutrition decreases normal gut flora and this increases the susceptibility to this infection. Hence, the use of broad-spectrum antibodies and poor nutrition amplify the incidence of typhoid fever.

While the United States reports only about 350-culture-confirmed cases of typhoid fever and fewer than 100 paratyphi. A case each year since 2008, enteric fever remains an important cause of illness worldwide. Approximately 215,000 deaths result from over 26 million cases of typhoid fever and 5 million cases of paratyphoid infection each year worldwide [14]. The number of new cases of typhoid fever has been increasing worldwide, due to rapid increases in population, pollution and shortages of pure drinking water. Still, death rates have decreased due to extensive research, changes in treatment modalities, and the invention of new drugs despite growing multi-drug resistance. In the era of routine antibiotics, classic presentation is not always seen. In the United States,

splenomegaly and rose spots may be seen in only 109 and 1.5% of the cases respectively [17].

Up to 4% of patients with typhoid fever go on to become chronic carriers. These patients remain asymptomatic after their acute treatment, but they may excrete *Salmonella* for up to 14 years in their stool, or less frequently their urine [17]. It is more commonly seen in women and those with biliary abnormalities, including cholelithiasis.

Blood group antigens may also be linked to susceptibility to S. typhi chronic carriage [11].

The pathogenesis of typhoid fever depends upon a number of factors, including infections species, virulence, host immunity and infectious dose. The larger the infectious dose, the shorter the incubation period and the higher the attack rate.

Typhoid fever is more severe in debilitated and immunocompromised patients such as those with HIV (mainly paratyphi), those on glucocorticoid therapy, and those with altered phagocytic function (i.e. patients with malaria and sickle cell anemia). *Salmonella* is an acid-sensitive bacteria except for a few resistance strains, so typically, it is destroyed in the stomach by gastric acid [11]. In patients with achlorhydia, intake of antacids and antihistamines, colonization of *Salmonella* occurs even with smaller doses. Food and beverages also act as buffers against gastric acid that facilitates bacteria reaching the small gut [10].

5. Conclusions

Malaria and typhoid have remained major infectious tropical diseases. Clinically, whenever there is severe malaria, cough is always an associated symptom owing to typhoid infection arising from poor hygiene in respect to drinking water and food. There is a strong association between human blood group and disease. Residual malaria transmission, effect on climate change on malaria vector composition, environmental management targeted at malaria breeding control as an intervention strategy are areas of interest to WHO in malaria control in Sub-saharan Africa [24]. A body of data is been built on susceptibility of human blood groups to malaria, HIV and HBV and presently malaria and typhoid. If climate change warrants a change in composition of vectors and as well resistance to ACT therapy, the susceptibility or vulnerability of the human blood group is also called into question. The link between susceptibility of human blood group to malaria and typhoid has not been previously investigated in detail in a Nigerian setting.

The present study has assessed the genetic disposition (susceptibility of human blood groups and ABO analysis) to malaria and typhoid infections.

From the one hundred (100) patients screened for malaria and typhoid infections in a tertiary health facility—His Glory Hospital Lagos, Nigeria, and Blood samples collected by venu-puncture from 53 females and 47 males adults aged between 15 – 47 years, who were infected either singly or coinfected with malaria and typhoid, and analyzed for microscopic detection of P. falciparum, widal se-

rological technique for salmonella antibody presence and genotypic determination done using standard WHO methods, and the resulting human material or data analyzed or performed in accordance with the declaration of Helsinki (2000). The results obtained and expressed in percentage frequency show that genotype AA was more susceptible to typhoid and malaria infections compared to AS and SS, also blood group O^+ was more susceptible to malaria and typhoid infection compared to blood groups A, AB and B, although, there is no significant difference between male and female gender, susceptibility to malaria infection, the female gender is more susceptible to typhoid than the male. The finding may be relevant to malaria susceptibility and genetics and thus provide baseline information on the management of the scourge.

Malaria and typhoid fever arguably still remain the best example of the impact that infectious diseases can have on the human genome while numerous genes have been identified that are strongly associated with the risk of different forms of malaria and typhoid fever. This is entirely consistent with the fact that for all but a brief period during the incubation phase, the biological success of malaria parasites and *Salmonella typhi* in humans is entirely dependent on their ability to invade, grow and survive within their internal milleu.

Further studies with large sample sizes are ongoing to reaffirm and revalidate these findings as well as to ascertain why those with genotype AA are more susceptible to malaria and typhoid infection. Also why those with O^+ blood group have been more susceptible to malaria and typhoid infection. Research is also ongoing to know if there are other factors that can cause those with genotype AA to be more susceptible to malaria and typhoid infection, through the evaluation of their biochemical mechanism of susceptibility. We conclude that genotype AA and blood group O+ are more susceptible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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