Ethnic Variations in Hematological Responses to Malaria: A Study of Gouin and Fulani Children in West Africa

Analysis Report

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Abstract

Hematological tests play a crucial role in early malaria diagnosis and management, particularly in resource-limited regions. This study investigates the hematological differences between Gouin and Fulani children in West Africa, focusing on their responses to *Plasmodium falciparum* malaria. Utilizing public data from a previous metabolomic study, I analyzed key parameters such as white blood cell count, monocyte percentage, lymphocyte/neutrophil ratio, hemoglobin levels, and parasitemia. The results indicate that Gouin children exhibit higher white blood cell counts and parasitemia levels, suggesting a more intense immune response and higher parasitic burden. In contrast, Fulani children display higher monocyte percentages and lymphocyte/neutrophil ratios, indicative of more effective immune regulation and a robust adaptive immune response.

The study highlights the critical role of hematological tests for early malaria diagnosis and management, particularly in regions with limited healthcare resources. Our findings emphasize the influence of ethnic factors on immune responses to malaria, with the Fulani ethnicity demonstrating an intrinsic immunological advantage. These insights are essential for developing targeted diagnostic and treatment strategies to enhance malaria outcomes in endemic areas. Future research should include larger, balanced samples and integrate metabolomic data to provide a more comprehensive understanding of these hematological differences and their implications for malaria management.

Background/Introduction

The study of varying host responses to *Plasmodium falciparum* has highlighted many differences between ethnic groups of children in West Africa, showing the immunosuppressive role of steroids. The Fulani ethnicity is more resilient to Plasmodium falciparum malaria compared to the Gouin ethnicity. When looking more in depth into this study, the focus was largely on metabolomics with infection (Abdrabou et al., 2021). A biochemical standpoint is valuable in many aspects, but from an epidemiological standpoint, it is important to understand the lack of diagnoses ability in areas such as the one studied upon. Hematological abnormalities offer valuable insights into the physiological processes within the body, shedding light on the presence of malaria or other conditions associated with malarial infections. In malaria-endemic zones, where various illnesses may present with similar symptoms, blood tests serve as a crucial initial diagnostic tool, enabling prompt treatment initiation, particularly in areas where access to comprehensive healthcare may be limited (Jairajpuri et al., 2014). In this study, I conducted a comprehensive analysis and statistical evaluation of hematological parameters and parasitemia fluctuations among both infected and non-infected children in West Africa. Additionally, I compared these dynamics between two distinct ethnic groups within the region.

Methods

This study uses public data from the previous metabolomic study done on ethnic groups in West Africa. A total of 150 children were examined for the Gouin ethnicity, whereas 53 children were examined for the Fulani ethnicity (Abdrabou et al., 2021). For everyone involved in the study, levels of hemoglobin, log2 Parasitemia, the ratio of lymphocytes over neutrophils, white blood cell count, and monocytes were used to determine hematological differences. The blood was taken from non-infected individuals and followed up to when they were eventually infected with *Plasmodium falciparum* and because of this, some of the data was unmatched. The statistical analysis conducted encompassed a range of techniques, including Welch's t-test to compare means between groups, likelihood ratio tests to assess model fit, examination of mean differences, and the generation of correlational heatmaps to visualize relationships among variables. A shiny app dashboard was created for an interactive analysis environment.

Results

A likelihood ratio test was used to firstly understand if a model using ethnicity and infection status was better than a model with no predictor variables. In Table 1, when considering Ethnicity and Infection Status, it is a much better model than without predictor variables, therefore continuing analysis took place.

The comparison between Gouin and Fulani ethnicities using Welch's t-test, when looking at Table 2, reveals several significant differences in health parameters. The Gouin show a significantly higher white blood cell count (8.02) compared to the Fulani (7.23), with a p-value of 0.032. In contrast, the Fulani have a higher percentage of monocytes (10.7%) than the Gouin (7.87%), with a highly significant p-value of 7.962e-8. Additionally, the Fulani exhibit a much higher ratio of lymphocytes to neutrophils (4.27) compared to the Gouin (1.22), with an extremely significant p-value of 1.1077e-40. The Gouin also have significantly higher log2 parasitemia levels (13.6) than the Fulani (9.25), with a p-value of 1.515e-18. There is no significant difference in hemoglobin levels or age between the two groups.

Illustrated in Table 3, gender-based comparisons within each ethnicity show no significant differences in white blood cell count, monocyte percentage, lymphocyte/neutrophil ratio, hemoglobin levels, or log2 parasitemia for both the Gouin and Fulani. This suggests that gender does not influence these health parameters significantly within each ethnic group.

Infection status reveals more pronounced differences based on Table 4. Infected Gouin individuals have a significantly higher white blood cell count (9.058) than non-infected individuals (7.272), with a p-value of 0.01403. Infected Gouin also have a significantly lower lymphocyte/neutrophil ratio (0.692) compared to non-infected individuals (1.76), with a p-value of 0.003, and significantly lower hemoglobin levels (10.411) than non-infected individuals (11.266), with a p-value of 1.517e-7. Among the Fulani, there are no significant differences in white blood cell count, monocyte percentage, or age based on infection status, but infected

individuals have significantly lower hemoglobin levels (10.621) compared to non-infected individuals (11.337), with a p-value of 0.00375.

When comparing infected individuals across ethnicities, via Table 5, infected Gouin have a significantly higher white blood cell count (9.06) compared to infected Fulani (7.20), with a p-value of 0.0106. The Fulani have a higher monocyte percentage (11.9%) compared to the Gouin (10.3%), with a p-value of 7.10e-10. Infected Fulani also exhibit a higher lymphocyte/neutrophil ratio (4.15) compared to infected Gouin (0.692), with a p-value of 1.700e-71. Notably, the Fulani are significantly older than the Gouin, both among infected and non-infected individuals, with highly significant p-values.

These findings highlight significant ethnic differences in immune response and infection characteristics, with notable variations in white blood cell count, monocyte percentage, lymphocyte/neutrophil ratio, and hemoglobin levels, particularly influenced by infection status. Gender does not appear to significantly influence these parameters within each ethnic group.

Discussion

This study highlights significant hematological differences between Gouin and Fulani children in West Africa, emphasizing the Fulani's greater resilience to Plasmodium falciparum malaria. Our analysis aligns with the datasets study's findings (Abdrabou et al., 2021) and offers deeper insights into the physiological responses to malaria within these ethnic groups.

Infection status notably affected Gouin children's hematological parameters, with higher white blood cell counts and lower lymphocyte/neutrophil ratios in infected individuals. Infected Gouin also had significantly lower hemoglobin levels. Among Fulani children, only hemoglobin levels differed significantly with infection status, highlighting their more stable hematological profile in response to malaria. Cross-ethnic comparisons reveal that infected Gouin children have higher white blood cell counts and lower lymphocyte/neutrophil ratios compared to infected Fulani children, emphasizing a more intense immune response in the Gouin. The consistently higher monocyte percentages and lymphocyte/neutrophil ratios in Fulani children suggest an intrinsic immunological advantage.

The study underscores the importance of hematological tests for early malaria diagnosis in endemic regions. Significant differences in white blood cell count, monocyte percentage, lymphocyte/neutrophil ratio, and hemoglobin levels serve as valuable markers for detecting and monitoring malaria, especially in areas with limited healthcare access. However, limitations include the use of public data, unmatched data points, and small sample sizes, particularly for the Fulani group. Future research should focus on larger, balanced samples and longitudinal data to understand the temporal dynamics of hematological changes in response to malaria. Integrating metabolomic and hematological data could further elucidate biochemical and physiological responses across different ethnicities.

In summary, this study highlights significant hematological differences between Gouin and Fulani children in response to malaria, providing valuable insights for tailored diagnostic and treatment strategies in malaria-endemic regions.

Conclusion

This study reveals critical hematological differences between Gouin and Fulani children in West Africa, highlighting the Fulani ethnicity's superior resilience to Plasmodium falciparum malaria. The Gouin exhibit elevated white blood cell counts and parasitemia levels, signaling a stronger immune response and higher parasitic burden, while the Fulani display higher monocyte percentages and lymphocyte/neutrophil ratios, indicating more effective immune regulation. These findings underscore the importance of hematological tests for early malaria diagnosis and management, particularly in regions with limited healthcare resources.

The results illustrate the significant impact of ethnic factors on immune responses to malaria, with Fulani ethnicity demonstrating an inherent immunological advantage. Understanding these differences is crucial for developing targeted diagnostic and treatment strategies to improve malaria outcomes in endemic areas. Future research should involve larger, balanced samples and integrate metabolomic data to further clarify these hematological distinctions and their implications for malaria management.

Citations

Abdrabou, W., Dieng, M.M., Diawara, A., Serme, S.S., Almojil, D., Sombie, S., Henry, N.B., Kargougou, D., Manikandan, V., Soulama, I., Idaghdrour, Y. (2021). Metabolome modulation of the host adaptive immunity in human malaria. *Nature Metabolism. 3,* 1001-1016. https://doi.org/10.1038/s42255-021-00404-9

Jairajpuri, Z. S., Rana, S., Hassan, M. J., Nabi, F., & Jetley, S. (2014). An Analysis of Hematological Parameters as a Diagnostic test for Malaria in Patients with Acute Febrile Illness: An Institutional Experience. Oman medical journal, 29(1), 12–17. https://doi.org/10.5001/omj.2014.04

Appendix

Table 1

Likelihood Ratio for hematological characteristics comparing Model 1 (considering Ethnicity and Infection Status with Model 2 (no predictor variables)

Variables	**Likelihood Ratio**	***p***
White Blood Cell Count	9.270	0.001
Monocytes (%)	86.305	2.2e-16
Ratio Lymphocytes/Neutrophils (%)	134.19	2.2e6-16
Hemoglobin	35.773	1.706e-8

Table 2

Welch's t-test for Ethnicity vs. Hematological variables and age in months

Variables	**Gouin**	**Fulani**	**Welch's t-test**
	M	M	*p*
White Blood Cell Count	8.02	7.23	0.032
Monocytes (%)	7.87	10.7	7.962e-8
Ratio Lymphocytes/Neutrophils (%)	1.22	4.27	1.1077e-40
Hemoglobin	10.7	11.0	0.124
Log2 Parasitemia	13.6	9.25	1.515e-18
Age (Months)	65.6	103	6.590e-25

Table 3

Welch's t-test for Ethnicity by Gender vs. Hematological variables

	Gouin		**Welch's T-test**	**Fulani**		**Welch's T-test**
Variables	Male	Female		Male	Female	
	M	M	*p*	M	M	*p*

White Blood Cell Count	8.00	8.06	0.926	7.33	7.16	0.539
Monocytes (%)	7.85	7.90	0.940	11.4	10.2	0.105
Ratio Lymphocytes/Neutrophils (%)	1.42	0.969	0.172	4.32	4.25	0.415
Hemoglobin	10.8	10.7	0.515	10.8	11.1	0.168
Log2 Parasitemia	13.4	13.9	0.374	9.14	9.32	0.374

Table 4

Welch's t-test of Ethnicity by Infection Status vs. Hematological characteristics

	Gouin		**Welch's T-test**	**Fulani**		**Welch's T-test**
Variables	Infected	Non-Infected		Infected	Non-Infected	
	M	M	*p*	M	M	*p*
White Blood Cell Count	9.058	7.272	0.01403	7.20	7.26	0.842
Monocytes (%)	10.2	5.41	1.961	12.2	9.17	1.127
Ratio Lymphocytes/Neutrophils (%)	0.692	1.76	0.003	4.15	4.39	0.003
Hemoglobin	10.411	11.266	1.517e-7	10.621	11.337	0.00375
Age (Months)	66.700	64.444	0.448	102.717	102.717	1

Table 5

Welch's t-test based on Infection Status by Ethnicity vs. Hematological Variables

	Infected			**Non-Infected**		
Variables	Gouin M	Fulani M	*p*	Gouin M	Fulani M	*p*
White Blood Cell Count	9.06	7.20	0.0106	7.27	7.27	0.980
Monocytes (%)	10.3	11.9	7.10e-10	10.3	9.08	3.52e-2
Ratio Lymphocytes/Neutrophils (%)	0.692	4.15	1.700e-71	1.77	4.41	4.39e-11
Hemoglobin	10.4	10.6	0.319	11.3	11.3	0.720
Age (Months)	66.7	102.717	1.46e-12	64.444	102.717	1.27e-13

Other Resources:

The Shiny app dashboard is available through the link https://madisonbeardslee.shinyapps.io/dashboard/.