ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS | Volume VIII Issue I January 2023

Detecting Malaria Susceptibility in Patients Using Fingerprint Pattern

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Received: 28 December 2022; Revised: 07 January 2023; Accepted: 09 January 2023; Published: 29 January 2023

ABSTRACT:- In most malarious regions of the world, detection of the malaria parasite caused by Plasmodium falciparum is a primary concern due to inadequate or non-existence of appropriate health facilities. This study aimed to detect malaria susceptibility in patients using fingerprint patterns. Giemsa's staining and live scan techniques were used for sample collection. A total of 165 individuals confirmed with different degrees of Plasmodium falciparum parasitaemia were enrolled. The most extensive fingerprint pattern was the loops (51.36%), followed by the whorls (32.12%) and arches (16.36%). The level of parasitaemia was 140 (84.85%) one plus "+", 20 (12.12%) two pluses"++" and 5(3.03%) three pluses "+++". The age groups were 27.88% (18-22 years), 30.91% (23-27 years), 14.51% (28-32 years), 14.51% (33-37 years), 7.27% (38-42 years) and 4.81% (43-47 years) respectively. Our findings revealed a high degree of parasitaemia in patients with loop fingerprint pattern, both in gender and across age groups. Though the distribution of the fingerprint pattern against malaria susceptibility ($X^2 = 0.850$, $p > 0.932$), gender ($X^2 = 5.695$, $p > 0.058$) and age group ($X^2 = 13.53$, $p > 0.195$) were not significant, individuals with loop fingerprint pattern were more prone to malaria susceptibility. A paired sample t-test analysis of fingerprint patterns revealed significant differences in the age group of patients ($p<0.002$), malaria parasitaemia ($p<.001$) and gender ($p<.001$). This study however lays a foundation for further studies on the use of fingerprints in detecting susceptibility to infectious clinical diseases.

Keywords: Malaria parasite, susceptibility, fingerprint, patients, pattern

I. INTRODUCTION

Worldwide, the number of cases of malaria caused by *Plasmodium falciparum*, the most dangerous species of the parasites, is on the rise (Murray *et al.*, 2012., Mace *et al.*, 2021, WHO, 2021a). Malaria continues to cause unacceptably high levels of disease and death, as documented in successive editions of the World malaria report (WHO, 2021b). According to the latest report, there were an estimated 241 million cases and 627 000 deaths globally in 2020 (WHO, 2022b) Over the past four decades, efforts to detect and control malaria have met with less and less appreciable success. The situation in many African nations is particularly dismal, exacerbated by a crumbling health infrastructure that has made the implementation of any disease detection and control program difficult (Stanley et al., 1991). This situation calls for urgent attention.

Artemisinin-based combination therapy (ACT) was introduced some years ago for the treatment of malaria particularly *P. falciparum.* The treatment has been found effective overtime, as it reduces the disease burden, transmission and prevention of deaths (Luiz et al., 2018; WHO, 2021; WHO Guideline, 2022b). However, the world Health organization recommends that all suspected cases of malaria be confirmed using Parasite Based Diagnostic Testing before administering treatment (WHO, 2022a). This testing approach enables health providers to swiftly distinguish between malarial and non-malarial fevers and select the most appropriate treatment (WHO, 2004, 2017, 2018). It is noted however, that malaria presents a diagnostic challenge to laboratories in most countries especially third world. The urgency and importance of obtaining quick results from the examination of blood samples from patients with suspected acute malaria render some of the more sensitive methods for malaria diagnosis impractical for routine laboratory use (Anthony, 2002). The parasite based diagnostic testing requires the use of blood sample whose method of obtaining is invasive, and in the midst of lean health care facilities and resources, the method could be time consuming and error prone. The need therefore to uncover an uninvasive approach to the use of blood testing mechanism in detecting individual susceptibility to P. *falciparum*, is necessary.

In the third world countries with a high load of population, the simplicity of dermatoglyphic technique and its inexpensiveness warrants its continued use for evaluation as a diagnostic tool. When combined with other clinical and investigative features, dermatoglyphic study can serve to strengthen a diagnostic impression and can be advocated as useful screening device (Sharma et al., 2018). Like the various physical evidences used for identification such as DNA profiling, Lip marks, foot prints, and bite marks, finger prints are constant and individualistic (Edgar, 2021). Their designs are exclusive in each human and the chance of two individuals having identical fingerprint is an exceptional case (Mittal and Lala, 2013).

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Dermatoglyphics is the study of stratum ridges on the hairless part of the palm, finger, toes and soles. It has been in use from time immemorial (Sudiskshya *et al.*, 2018). The distribution of these outgrowths or stratum ridges on the finger tips are protected throughout life (Smail *et al*., 2019) except when destroyed by decomposition of the skin (Bhavana *et al.*, 2013). For instance, the fingerprint pattern, such as the print left when an inked finger is pressed onto paper, represents the friction ridge pattern on that particular finger which are grouped into three distinct types: loops, arches and whorls; each having unique variations, depending on the shape and relationship of the ridges. The importance of dermatoglyphics lies in the morphological constancy of the dermal ridge arrangements from the time of formation until death (Jay *et al*., 2022).

The study of finger print is well documented on a number of important roles it plays in gender, age group classification, screening for abnormal anomalies, diagnosis of different diseases with genetic basis and relation to blood group system in some parts of the world (Paul and Lourde, 2006., Fayrouz *et al*., 2012, Lakshmi and Thenmozhi, 2014). Studies have shown that there is a relationship between finger print, various genetic factors and susceptibility to severe *P. falciparum* infection (Drouet, 2019). There is however paucity of information reported on the place of finger print and infectious diseases. Due to the immense potentials of fingerprint as an effective means of identification, the need to explore the relationship between finger print patterns and common clinical disease like malaria susceptibility is imperative.

This work is therefore aimed at using finger print pattern; a technique that is constant, individualistic, and easy to accomplish to determine individual's susceptible to Malaria infection. The study will enhance the skills and proficiencies of our laboratory scientist and physicians in predicting patients' status of infectious and other common clinical diseases without the conventionally invasive hematological and or pathological techniques. The outcome of this study will offer analysts or researchers the opportunity of using fingerprint analysis as perspective to further establish individuals' uniqueness in biomedical space.

II. MATERIALS AND METHOD

Study design

The study site was Keffi town, a local government area in Nasarawa State, Nigeria. The town is 50 kilometers from Abuja the Federal Capital of Nigeria and has a population of about 92,664 as at the 2006 population census (Wikipedia, 2015). A total of 198 participants made up of male and female within the ages of 18-47 years presented themselves for the screening but only 165 who were confirmed to be positive to various level of Plasmodium falciparum parasitaemia of malaria infection were recruited for the study.

Ethical approval and consent

Ethical approval was obtained from the ethics and grievances committee of the Federal Medical Center Keffi (Ref No: FMC/KF/HREC/004021) while oral consent was obtained from the subjects who offered to participate in the study upon meeting the criteria for the selection.

Sample collection and analysis

Blood samples were collected by trained Medical Laboratory Scientist in the facility using venipuncture technique. The arms of the patients were tied with tourniquet and the position of the veins were disinfected using swab soaked in methylated spirit. Blood samples were collected into Ethylene Diamine Tetra Acetic acid (EDTA) tubes and moved into the hematology unit for analysis. Sterile techniques and disposable, single use materials were used at all times.

Malaria parasite detection and count

Thick and thin blood films were made and stained using Giemsa's staining technique for malaria parasite detection and count respectively. Changes in parasitized red blood cells helped to identify the plasmodium species and to detect mixed infection of malaria parasite. The number of asexual P. *falciparum* and other species per 100 leukocytes were counted and if ten or more parasites were identified, then the number was recorded, blood samples were regarded as negative if the examination of thick films failed to show the presence of asexual parasites. The parasite count in relation in to the leukocyte count were converted to parasite per micro liter of blood (assuming 6000 leukocytes per micro liter of blood) using the formula below:

$$\text{Parasites/}\mu l \text{ of blood} = \frac{\text{No. of parasites counted}}{\text{No. of leukocyte counted}} \times 6000$$

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Fingerprint collection and analysis

The finger prints of all malaria-suspected patients were collected using a live scan method and analyzed as illustrated by Cummins and Midlo, (1943). The finger print patterns (loops, arches and whorls) were analyzed based on their features using human eyes, a small magnifier called loupe to view minute details (minutiae) of the print and a pointer called ridge counter to count the friction ridges. Fingerprint analysis process 'ACE-V (analysis, comparison, evaluation and verification) was used to reach a determination on each print. Loops for instance were accessed as the most ordinarily up-to-the-minute highlights on a person's fingerprints. Whose edges starts trickling out of a crosswise of the fingertip, circle from place to place the focal point of finger cushion, and back to a similar course where they began from. Because of an individual area of arm bones—Radia and Ulna, any loop opening endlessly from thumb is an ulnar loop, and the one which opens near the thumb is a radial loop (Hsieh *et al.*,2003., Hoover, 2012). The archis were assessed as tented patterns that are portrayed by a straight upstanding edge at the center of a straightforward arch pattern (Kanchan and Chattopahyay, 2006., Jain, 2015). While the whorls are portrayed by two deltas and one focal roundabout center which may come in various forms as winding, concentric circles, vertically compacted circles or the state of eye of a peacock quill. The edges start from one end, rise and hover towards the middle and go down towards the opposite end (Imaq, 2004., Hoover, 2012).

Figure 1a: 'Loop' .

Figure 1b: 'Arch'

Figure 1c: 'Whorl'

Statistical Analysis

The statistical analysis was performed using JASP 0.16.0 for descriptive analysis and comparism of categorical variables. The analysis of the data between different finger print patterns and malaria susceptibility were done using paired sample t-test and One-way ANOVA. Binomial analysis was also carried out where necessary. Graphs were represented by descriptive charts and raincloud plots to display the individual cases, while p-value < 0. 05 was considered statistically significant for all analysis.

III. RESULTS

Figures 2a -2d: shows the distribution of various characteristics of the population sampled. A total of 198 individuals were enrolled for the study but 165 were confirmed with different degree of malaria infection. Of this number, 140 (84.85%) were one plus "+", 20 (12.12%) were two pluses"++" while 5 (3.03%) were three pluses "+++" respectively (Fig. 2a). The population of subjects with loop finger print pattern were 85(51.36%), Arches were 27 (16.36%) while whorls were 53(32.12%) (Fig.2b). Eighty-Four (50.91%) of the subjects were males while 81(49.09%) were females (Fig.2c). The distribution of the age group recorded 46 (27.88%) subjects for the age group 18-22 years, 51 (30.91%) 23-27 years, 24 (14.51%) 28-32 years, 24 (14.51%) 33-37 years, 12 (7.27%) 38-42 years and 08 (4.81%)43-47 years respectively (Fig.2 d).

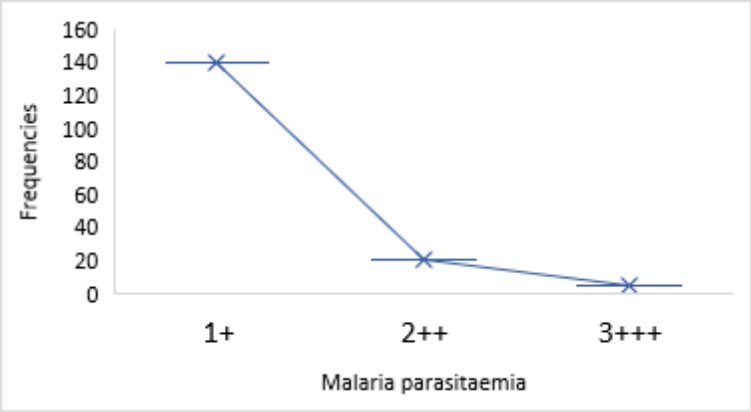

Figure 2a. Distribution of the sampled population based on the level of parasitaemia

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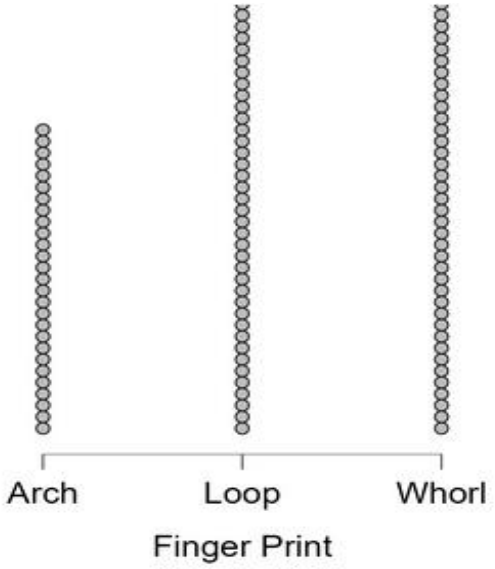

Figure 2b. Dot Plots showing the distribution of the fingerprint pattern of the sampled population

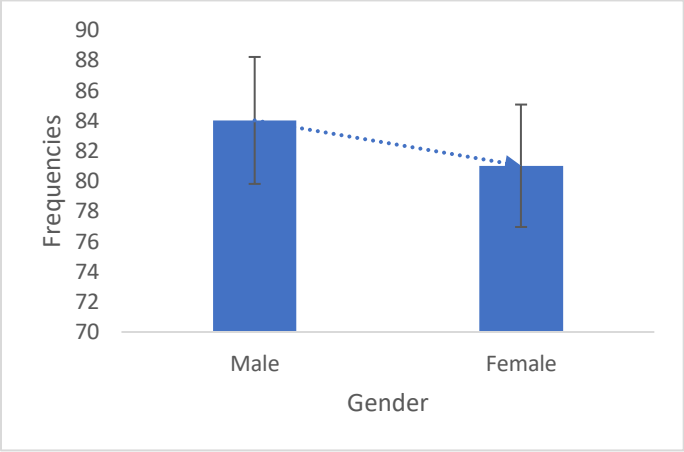

Figure 2c. Frequency of gender of the sampled population

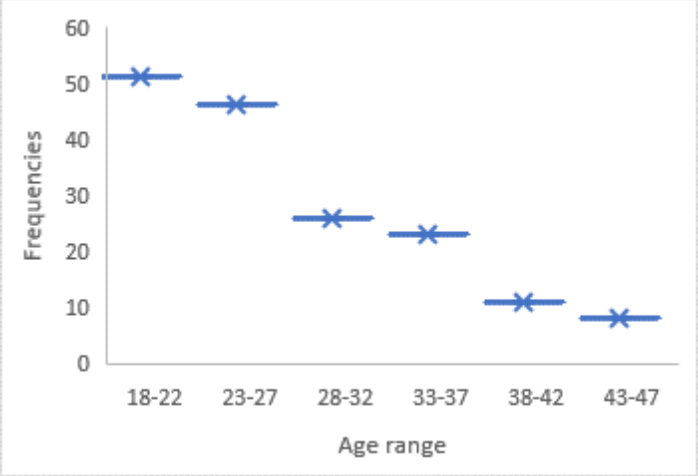

Figure 2d. Age range of the population sampled

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Figures 3a - c are represented by raincloud plots which displays the individual cases (colored dots), box plots, and densities for each measure. The cases from both measures are connected with individual lines. The x-axis and color represent the measures, and the y-axis represents the dependent variable. Within the box plots, the bold black line shows the sample median, the hinges indicate the 25th and 75th quantile, and the whiskers point to 1.5 interquartile ranges beyond the hinges. Densities are estimated using a Gaussian kernel and the bandwidth is determined with the 'nrd0' method (Silverman, 1986).

The distribution of the finger print pattern against susceptibility of individuals to the various degrees of malaria parasitaemia is shown in Figure 3a. Of the 85 patients who had loop finger print pattern, 72(84.71%) were one plus "+", 11 (12.94%) two pluses"++" and 2 (2.35%) were three pluses "+++" accordingly. Individuals who had Arch finger print pattern recorded 22 (81.48%) one plus "+", 4 (14.82%) two pluses"++" and 1(3.70%) three pluses "+++". While those who had whorl finger print pattern registered 46 (86.79%) one plus "+", 5 (9.43%) two pluses"++"and 2 (3.77%) three pluses "+++" respectively. 25 (15.15%) subjects of the sampled population were highly parasitaemic. The highest level of parasitaemia was observed amongst patients with loop finger print (13, 52%), followed by whorls (7, 28%). A Chi-square value of 0.850 and a non-significant value of p> 0.932 was obtained.

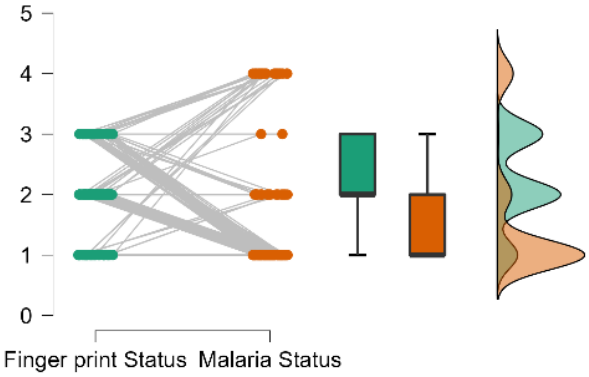

Fig. 3a. Finger print pattern and Malaria parasitemia in patients

Figure 3b. shows the distribution of finger print pattern against gender status of the malaria susceptible individuals. The figure reveals that male individuals with the loop finger print pattern were 39 (46.43%) while females was 46 (56.79%), 11 (13.10%) males had Arch finger print pattern while female had 16 (19.75%). Those with whorl finger print pattern were 34 (40.47%) male and 19 (23.46%) females accordingly. The analysis revealed that 13(52%) of the males were highly parasitaemic against 12(48%) of the female patients. A chi-square value of 5.695 and non-significant value of p> 0.058 were recorded.

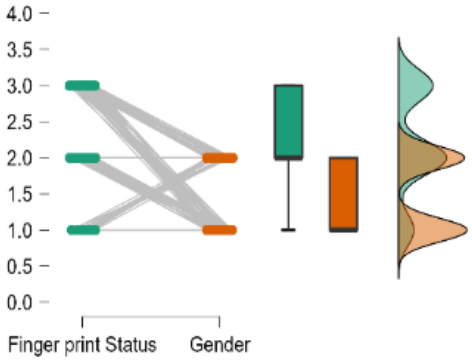

Figure 3b. Finger print pattern and Gender of malaria susceptible subjects

The relationship between the finger print pattern and the age groups of malaria susceptible individuals is represented in Figure 3c. The outcome indicates that Loop finger print pattern had 20 (23.53%) individuals between the ages of 18-22, 30 (35.29%) between 23-27, 11 (12.94%) between 28-32, 14 (16.47%) between 33-37, 5 (5.88%) between 38-42 and 5 (5.88%) between 43- 46 year respectively. The Arch finger print pattern had 7 individuals (25.93%) between the ages of 18-22, 8 (29.63%) between 23-27, 2 (7.41%) between 28-32, 3(11.11%) between 33-37, 4(14.82%) between 38-42, and 3 (11.11%) between 43-46 years. The level of

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parasitaemia was high in the age group 18-22 and 23-27 with 28% each and the age group 33-37 with 24%, age groups 28-32 and 38-42 had few subjects 2(8%) each with high level of parasitaemia. The least group was the age group 43-47 years with 1(4%). A Chi-square value of 13.53, and non-significant value of p> 0.195 were obtained.

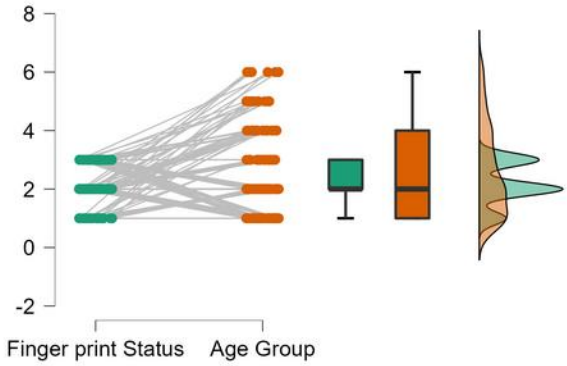

Figure 3c. Fingerprint pattern and age groups of malaria susceptible subjects

A paired sample t-test analysis was carried out to determine the relationship between finger print pattern and individuals with malaria parasitaemia, gender and age groups respectively (Table 1). The paired simple t-test analysis of the fingerprint pattern however revealed significant difference in the age group of patients (p<0.002), malaria parasitaemia (p<.001) and gender (p<.001).

Table 1: Paired sample t-test of finger print pattern against the various variables of the sampled population.

	t	df	p-value	Mean Difference	SE Difference	95% Cl for proportion		Chen's d
						Lower	Upper	
Malaria parasitaemia	15.040	164	< .001	0.976	0.065	0.848	1.104	1.171
Gender	9.450	164	< .001	0.667	0.071	0.527	0.806	0.736
Age group	-3.114	164	0.002	- 0.412	0.132	- 0.673	- 0.151	- 0.242

IV. DISCUSSION

Man's curiosity in the field of dermatoglyphics dates back through centuries, when Chinese used it as a basis for fortune telling. About the same period, ancient Indians believed that the presence of ten whorls destined a person to be a 'Chakravarti' meaning "an emperor"(Athanikar, 1986, Lakshmi and Thenmozhi, 2014). The aim of this work was to attempt to explore the detectability of malaria susceptibility using finger print patterns.

In this study, our findings revealed that the most extensive finger print pattern in the sampled malarious (*P. falciparum*) population was the loops (51.36%), followed by the whorls (32.12%) and arches patterns (16.36%) respectively. These results are similar for gender (where male individuals with the loop finger print were 46.43%, and females 56.79%, followed by whorls finger print 40.47% male and 23.46% females, and lastly, arches finger print where males had 13.10% and females 19.75%) and the age groups of the sampled population, where loop finger print patterns dominate. Zaitoon *et al*., (2021) in their study conducted on an ordinary population had similar outcome. They observed that loop pattern was the most extensive finger print pattern with 60%-70% of the population, followed by whorl pattern with 25%-35% while arch pattern recorded 5%. These findings are in contrast with the findings earlier reported by Jhinghan *et al.*, (1990).

Also, in their study on palmar dermatoglyphics in male cationic Schizophrenia, (a neural disorder in which the patient has impairment in perception and thought processing), Chandan et al., (2012) reported greater number of arches and loops, and less of whorls. Also, Uta, (1997) had posited that digital dermatoglyphics patients suffering from this syndrome have high frequencies of arches but fewer loops. Other similar findings were reported by Ţarcă and Barabolski, (2003) when they investigated subjects with Kannar's Syndrome (a pathology of dermatoglyphics caused by infantile autism).

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Ţarcă and Tuluc (2005) in stressing the significant roles played by dermatoglyphics in the diagnosis of diabetes mellitus using abnormalities in fingerprint patterns, maintained that Type I diabetic patients showed characteristic reduction in loops and notable increase in whorls and arches. While Type II patients showed increase in the frequency of whorls and decrease in ulnar loops which do not have significant changes in radial loops in both hands irrespective of their sexes. They also reported significant reduction in arches in the right hand of males and left hands of females.

The similarity between the outcome of our study and Zaitoon *et al*., (2021) could be tied to the nature of study which involves non-genetic disorders. Other studies that reported higher incidences of whorls and arches in their study focused on disease states that were more genetically predisposed. Could it imply that environment and possibly disease state has some influence in the development of finger print pattern? addressing this question would provide an opportunity for using finger print pattern with some precisions when considering it as a detective tool or additional screening tool for identifying early risk factors that may help prevent additional complications in various diseases. In providing explanation to the question, Rodger, (2018) posits that though the environment in the womb is influenced by factors including blood pressure, hormonal mix, maternal diet and any infections, the position of the foetus in the womb and the density of amniotic fluid around the foetal fingers as well as genes, are thought to play key roles in determining each individual pattern. These changes, it is argued, are visible and permanent markers of abnormal development in the nervous system and other areas that are developing in the womb at the same time.

The theory behind dermatoglyphics; the scientific study of fingerprints and disease links is that if the growth of limbs, organs or other tissues are disturbed in very early foetal life, there will also be changes in the configurations of finger and palm prints. Therefore, making our fingerprints, the tiny ridges and troughs in the skin unique. Implying that each unique pattern is produced by a combination of effects on the foetal fingers in the womb when they are formed between the 11th and 24th week of pregnancy (Bhat et al., 2014; Rodger, 2018).

One of the most important aspects of reporting malaria infections from laboratory diagnostic methods is the information gained from estimating the level of parasitemia present in a blood film. Morphological assessment of the parasites is critical for accurate interpretation, particularly noting development stages and the presence of hemozoin pigment-containing asexual parasites when reporting *P. falciparum* infections. The information may indicate the possibility of a more severe clinical situation, particularly cerebral involvement, owing to the release into the peripheral blood circulation of developing schizont stages of the parasites sequestered in the capillaries (Anthony, 2002). Malaria elimination therefore requires more sensitive and affordable techniques to detect asymptomatic infections, mainly to prevent transmission (Aschar et al., 2022)

Whereas there are well documented evidences on the important roles played by finger print pattern in the screening of abnormal anomalies and diagnosis of different diseases with genetic predisposition globally (Rodger, 2018; Jay et al., 2022), there is however, paucity of information in literature on the use of finger print in detecting common clinical disease like malaria. In our findings the degree of parasitaemia assessed, was high amongst patients with the loop fingerprint pattern, both in gender and across the age groups. Though, the distribution of the finger print pattern against malaria susceptibility ($X^2 = 0.850$, $p > 0.932$), gender ($x^2 = 5.695$, df 2, $p > 0.058$) and age group ($X^2 = 13.53$, df 10, $p > 0.195$) were not significant, there were indications that individuals with loop finger print pattern were prone to the various degrees of malaria parasitaemia. This was followed by whorls and arches respectively. A paired sample t-test analysis of fingerprint pattern however revealed significant difference in the age group of patients ($p<0.002$), malaria parasitaemia ($p<.001$) and gender ($p<.001$) respectively.

V. CONCLUSION

This study lays a foundation for further studies on the use of fingerprints in determining other infectious clinical diseases. Noting that the relevance of dermatoglyphics is not to diagnose, but to prevent by predicting a disease; not by defining an existing disease, but to identify people with the genetic predisposition to develop certain diseases. Malaria is preventable and treatable, and the global priority is to reduce the burden of disease and death while retaining the long-term vision of malaria eradication (WHO Guideline, 2022a). We are still optimistic that global eradication of malaria is possible in the foreseeable future with innovations on how to detect malaria susceptible individuals unfolding.

ACKNOWLEDGEMENT

We express our gratitude to the Management and Staff of the Medical center for availing use the facility and patients to conduct our research.

DECLARATION

FUNDING SOURCE(S) 'Not applicable'

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the local ethics committee of the Federal Medical Center Keffi (Ref No: FMC/KF/HREC/004021) while oral consent was obtained from the subjects who offered to participate in the study upon meeting the criteria for the selection.

CONFLICT OF INTEREST

The authors declare that they have no financial or other relationships that might lead to any conflict of interest.

AUTHOR'S CONTRIBUTIONS

Each author contributed in varied significant parts towards the success of this research work.

HIGHLIGHTS

Malaria is preventable and treatable; this study however lays a foundation for further studies on the use of fingerprints in determining other clinical infectious diseases.

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