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Original Article

Host immune responses to mono-infections of *Plasmodium* spp., hepatitis B virus, and *Mycobacterium tuberculosis* as evidenced by blood complement 3, complement 5, tumor necrosis factor-α and interleukin-10

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ABSTRACT

Background: Mono-infections of *Plasmodium* spp., hepatitis B virus (HBV), and *Mycobacterium tuberculosis* could elicit activation of complements for innate immunity leading to inflammatory responses. **Objective:** This work was designed to determine host immune responses to mono-infections of *Plasmodium* spp., HBV, and *M. tuberculosis* in blood complement 3 (C3), complement 5 (C5), tumor necrosis factor-alpha (TNF-α), and interleukin 10 (IL-10). **Materials and Methods:** Of 200 volunteers 66 *Plasmodium* spp., mono-infected, 28 HBV mono-infected, 12 *M. tuberculosis* mono-infected and 62 noninfected volunteers were studied as test and controls. ELISA was used to determine HBV, hepatitis C virus (HCV), HIV, plasma C3, C5, IL-10, and TNF-α while *Plasmodium* spp., was identified by Geimsha thick-film microscopy and *M. tuberculosis* by immunofluorescence microscopy. **Results:** The results obtained in the 200 volunteers showed. 69% (138) were infected with one or more of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 31% (62) were not infected; 16% (32) had co-infections of at least two of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis;* 33% (66) were *Plasmodium* spp., mono-infected 14% (28) were HBV mono-infected while 6% (12) were *M. tuberculosis.* mono-infected. There was a significant increase in the plasma C3 in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and control ($P < 0.05$). There was a significant increase in the plasma C3 in *Plasmodium* mono-infection compared with HBV mono-infection and control ($P < 0.05$) There was a significant decrease in the plasma C3 in the results obtained in HBV mono-infection compared with the control ($P < 0.05$). There was a significant increase in the plasma C5 in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and control ($P < 0.05$). There was a significant increase in the plasma

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C5 in *Plasmodium mono-infection* compared with HBV mono-infection ($P < 0.05$). There was a significant decrease in plasma IL-10 and increased plasma TNF-α in *Plasmodium*, *M. tuberculosis,* and HBV mono-infections compared with the control ($P < 0.05$). There was also a significant increase in plasma TNF-α in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection ($P < 0.05$). **Conclusion:** There was an evidence of host immune responses as evidenced by a significant increase in plasma C3, C5, and TNF-α including a decrease in IL-10 in mono-infections of *Plasmodium* spp., HBV and *M. tuberculosis.*

Key words: Complements, cytokines, hepatitis B virus, *Mycobacterium tuberculosis* *Plasmodium* spp.

INTRODUCTION

Complements are small proteins produced by the liver and circulate as inactive precursors in the blood.[1-3] They promote the ability of antibodies and phagocytic cells to clear pathogens and destroy cells from an organism, promote inflammation, and attack pathogen cell membrane.[4,5] Complements works in conjunction with antibody to protect the body from invasion by pathogens through classical or alternative pathway.[1-3] They act on cell membranes to cause cell death.[1-3] They are stimulated by triggers leading to the cleavage of proteases in complement system with their corresponding proteins for the release of cytokines which will cause stimulation of phagocytes to remove foreign and damaged cells/materials, bring about inflammation to attract additional phagocytes, and activation of the cell-killing membrane attack complex.[1-3] Malfunction of the complement system can lead to fatal diseases and infections.[4,5]

Complement 3 (C3) C3 is majorly produced by the liver cells.[6] It is one of the proteins of the immune system that plays a central role in the activation of complement system and also contributes to innate immunity.[6,7] Individuals who are deficient of C3 are susceptible to bacterial infection.[6,7] Decreased blood C3 levels have been associated with systemic lupus erythematous, postinfectious glomerulonephritis, membranoproliferative glomerulonephritis, and shunt nephritis. The level rises in the inflammatory process as part of the acute-phase plasma protein response.[6,7]

Complement component 5 plays a significant role in inflammatory and cell destruction processes.[8,9] Deficiency of complement 5 can lead to risks of severe recurrent infections, susceptibility to liver fibrosis, and rheumatoid arthritis.[8,9]

Tumor necrosis factor-alpha (TNF-α) is a pro-inflammatory cytokine produced majorly by activated macrophages and other cells such as CD4+ lymphocytes, NK cells, neutrophils, mast cells, eosinophils, and neurons.[10,11] It regulates immune cells. It is an endogenous pyrogen as it induces fever, apoptotic cell death, inflammation, inhibits tumor cell growth including viral replication.[10,11]

Interleukin 10 (IL-10) is an anti-inflammatory cytokine that can inhibit the production of pro-inflammatory cytokines such as IFN-γ, IL-2, IL-3, TNF-α, and GM-CSF but stimulates B-cell maturation and antibody production.[12,13] It is a human cytokine synthesis inhibitory factor (CSIF).[12,13]

Infections of *Plasmodium*, hepatitis B virus (HBV), hepatitis C virus (HCV), HIV, and *Mycobacterium tuberculosis* are triggers of activation of complements, which can bring about inflammatory responses which could lead to a significant immunological alterations in plasma C3, C4, TNF-α, and IL-10.[1,2,6,7,10,11]

MATERIALS AND METHODS

Study area

Saki West is a Local Government Area in Oyo State, Nigeria. Its headquarters are in the town of Saki. Saki, Nigeria, is located at the extreme end of Oyo State. It has a Resettlement Center of 2nd Mechanized Division of Nigerian Army, The Oke-Ogun Polytechnic, Baptist Medical Centre, Muslim Hospital, Baptist School of Nursing, School of Medical Laboratory Technology, Oyo State Hospital and a Technical College. Saki, Nigeria, is also one of the largest cities in Oyo state. It shares a border with Kwara state and Burkina Faso.

Study design and study population

Two hundred volunteers (100 – females; 100 – males, aged 19–73 years) were recruited from Saki-West local government area of Oyo State-Nigeria. They were tested for *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis* infections. 69% (138 of the 200 volunteers) were infected with one or more of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*. 31% (62 of the 200) volunteers were not infected with any of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis* and as such were recruited as controls. Sixteen percent (32 of 200 volunteers) had co-infections of at least two of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 33% (66 of 200 volunteers) were mono-infected with *Plasmodium* spp., 14% (28 of 200 volunteers) were mono-infected with HBV while 6% (12 of 200 volunteers) were mono-infected with *M. tuberculosis*. Volunteers who were *Plasmodium*, HBV *and M. tuberculosis* and those not infected with *Plasmodium*,

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HBV, HCV, HIV, and *M. tuberculosis* volunteers were studied as test and control volunteers, respectively.

Biological samples

Five milliliters of venous blood samples were obtained from each subject into Lithium heparinized anticoagulated bottle to determine plasma C3, C5, IL-10. TNF-α *Plasmodium*, HBV, HCV, and HIV infections while sputum samples were obtained from each subject for identification of *M. tuberculosis*.

Methods

Human complement C3 assay using Randox kit

This was carried out using Randox kit.

Human complement C5 assay

This was carried out using Abcam enzyme-linked immunosorbent assay (ELISA) kit.

Tumor necrosis factor-alpha ELISA

Plasma TNF-α was analyzed using Abcam's TNF-α human *in vitro* ELISA kit.

Interleukin-10 enzyme-linked immunosorbent assay

Plasma IL-10 was analyzed using Abcam's kit. Abcam's IL-10 Human *in vitro* ELISA kit is designed for the quantitative measurement of IL-10 in supernatants, buffered solutions, serum, and plasma samples.

Laboratory identification of Plasmodium spp.,

Laboratory diagnosis of malaria was carried out by Microscopy using Giemsa-Thick film method as described by Cheesbrough.[14]

Anti-hepatitis C virus enzyme-linked immunosorbent assay

This was assayed using anti-hepatitis C virus core antigen antibody Abcam kit.

HIV enzyme-linked immunosorbent test

HIV test was carried out using Genscreen™ ULTRA HIV Ag-Ab Bio-Rad kit.

The Genscreen™ ULTRA HIV Ag-Ab is an enzyme immunoassay based on the principle of the sandwich technique for the detection of HIV antigen and of the various antibodies associated with HIV-1 and/or HIV-2 virus in human serum or plasma.

HBsAg enzyme-linked immunosorbent test

This was assayed using Diagnostic Automation/Cortez Diagnostics, INC kit by ELISA method.

The identification of *M. tuberculosis* in sputum is using fluorescence microscopy (auramine-rhodamine staining).

Principle

The specimen is illuminated with light of a specific wavelength (or wavelengths), which is absorbed by the fluorophores, causing them to emit light of longer wavelengths (i.e., of a different color than the absorbed light). The illumination light is separated from the much weaker emitted fluorescence through the use of a spectral emission filter. Typical components of a fluorescence microscope are a light source (xenon arc lamp or mercury-vapor lamp are common; more advanced forms are high-power light-emitting diodes and lasers), the excitation filter, the dichroic mirror (or dichroic beam splitter), and the emission filter. The filters and the dichroic beam splitter are chosen to match the spectral excitation and emission characteristics of the fluorophore used to label the specimen.[15] In this manner, the distribution of a single fluorophore (color) is imaged at a time. Multi-color images of several types of fluorophores must be composed by combining several single-color images.[15]

Most fluorescence microscopes in use are epifluorescence microscopes, where excitation of the fluorophore and detection of the fluorescence are done through the same light path (i.e., through the objective). These microscopes are widely used in biology and are the basis for more advanced microscope designs, such as the confocal microscope and the total internal reflection fluorescence microscope.

Ethical considerations and clearances

The proposal of this work was reviewed and approved by Ethical and Research Committee of Baptist Medical Center Saki-Nigeria before the commencement of this work. Informed consent was also obtained from each of the patient and controls.

Method of statistical analysis

The results obtained were subjected to statistical analysis using SPSS 18.0 (IBM, New York) to determine mean, standard deviation, probability, Student's *t*-test, and level of significance at 0.05.

RESULTS

The results obtained showed that. 69% (138 of the 200 volunteers) were infected with one or more of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 31% (62 of the 200) volunteers were not infected with any of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*. 16% (32 of 200 volunteers) had co-infections of at least two of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 33% (66 of 200 volunteers) were mono-infected with *Plasmodium* spp.,14% (28 of 200 volunteers) were mono-infected with HBV while

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6% (12 of 200 volunteers) were mono-infected with *M. tuberculosis* [Figure 1].

There was a significant increase in the plasma C3 in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection, and in the controls [$P < 0.05$; Tables 1, 2 and Figure 2]. There was a significant increase in the plasma C3 in the results obtained in *Plasmodium mono-infection;* compared with HBV mono-infection and control subjects [$P < 0.05$; Tables 1, 2 and Figure 2]. There was a significant decrease in the plasma C3 in the results obtained in HBV mono-infection compared with the controls [$P < 0.05$; Tables 1, 2 and Figures 2, 3].

There was a significant increase in the plasma C5 in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and in the control subjects [$P < 0.05$; Tables 1, 2 and Figure 2]. There was a significant increase in the plasma C5 in the results obtained in *Plasmodium mono-infection* compared with HBV mono-infection [$P < 0.05$; Tables 1, 2 and Figure 2]. There was no significant difference in the plasma C5 in the results obtained in HBV mono-infection, *Plasmodium mono-infection* compared with the results obtained in the control subjects [$P > 0.05$; Tables 1, 2 and Figures 2, 3].

There was a significant decrease in the plasma IL-10 in the results obtained in *M. tuberculosis* mono-infection, *Plasmodium* mono-infection, HBV mono-infection compared with the results obtained in the control subjects [$P < 0.05$; Tables 1, 2 and Figures 2, 3]. There was no significant difference in the plasma IL-10 in the results obtained in *M. tuberculosis* mono-infection, *Plasmodium* mono-infection and HBV mono-infection [$P > 0.05$; Tables 1, 2 and Figures 2, 3].

There was a significant increase in the plasma TNF-α in the results obtained in *Plasmodium* mono-infection compared with the controls ($P < 0.05$; Tables 1, 2 and

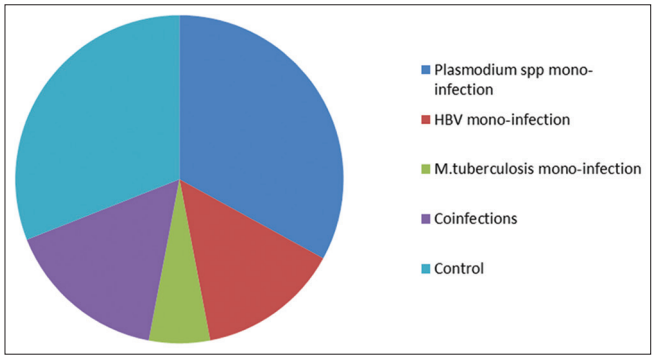

Figure 1: Frequency of the mono- and co-infections of *Plasmodium* spp., hepatitis B virus, and *Mycobacterium tuberculosis* and control

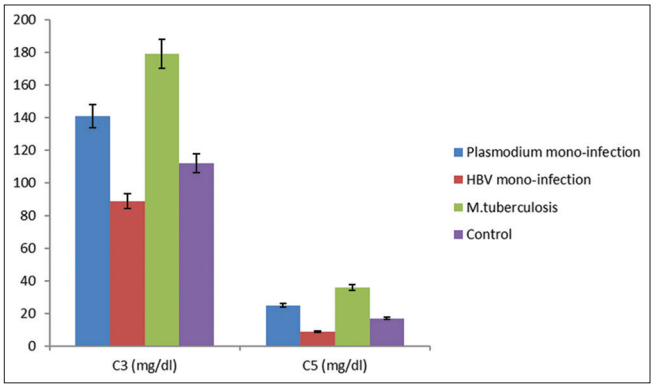

Figure 2: Comparative description of plasma C3 and C5 in mono-infections of *Plasmodium* spp., hepatitis B virus and *Mycobacterium tuberculosis*

Table 1: Mean and standard deviation of plasma (C3, C5), tumor necrosis factor-alpha and interleukin-10 in mono-infections of *Plasmodium* spp., hepatitis B virus, and *Mycobacterium tuberculosis*

	Plasmodium mono-infection (33%; 66)	HBV mono-infection (14%; 28)	*M. tuberculosis* mono-infection (6%; 12)	Control (6%; 62)
C3 (mg/dl)	141.0±6.0	89.0±5.0	179.0±6.0	112±5.0
C5 (mg/dl)	25.0±3.0	9.0±1.0	36.0±2.0	17.0±3.0
IL-10 (pg/ml)	2.7±0.2	2.4±0.3	2.0±0.2	4.0±0.2
TNF-α (pg/ml)	4.5±0.3	3.7±0.2	5.6±0.2	2.2±0.4

TNF-α: Tumor necrosis factor-alpha, IL-10: Interleukin-10, *M. tuberculosis*: *Mycobacterium tuberculosis*, HBV: Hepatitis B virus

Table 2: Comparative analysis of mean and standard deviation of plasma (C3, C5), tumor necrosis factor-alpha and interleukin-10 in mono-infections of *Plasmodium* spp., hepatitis B virus and *Mycobacterium tuberculosis*

	Plasmodium mono-infection versus HBV mono-infection (*t, P*)	*Plasmodium* mono-infection versus *M. tuberculosis* mono-infection (*t, P*)	*Plasmodium* mono-infection versus control (*t, P*)	HBV mono-infection versus *M. tuberculosis* mono-infection (*t, P*)	HBV mono-infection versus control (*t, P*)	*M. tuberculosis* mono-infection versus control (*t, P*)
C3 (mg/dl)	6.6579, 0.011*	4.4783, 0.023*	3.7131, 0.03*	−11.5233, 0.004*	−3.2527, 0.042*	8.5785, 0.007*
C5 (mg/dl)	5.4252, 0.02*	−3.0509, 0.046*	1.8856, 0.1	−12.0748, 0.0034*	−2.5298, 0.06	5.2697, 0.017*
IL-10 (pg/ml)	0.8321, 0.25	2.4749, 0.066	−4.5962, 0.02*	1.1094, 0.191	−4.4376, 0.024*	−7.0711, 0.01*
TNF-α (pg/ml)	2.219, 0.078	−3.0509, 0.0463*	4.6, 0.022*	−6.7175, 0.011*	3.3541, 0.04*	7.6026, 0.008*

*Significant. TNF-α: Tumor necrosis factor-alpha, IL-10: Interleukin-10, *M. tuberculosis: Mycobacterium tuberculosis*, HBV: Hepatitis B virus

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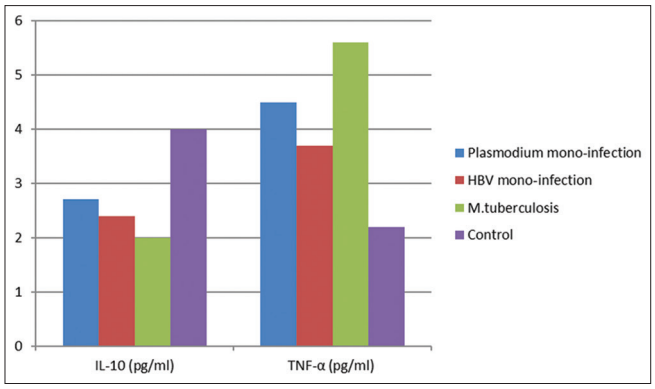

Figure 3: Comparative description of plasma tumor necrosis factor-alpha and interleukin-10 in mono-infections of *Plasmodium* spp., hepatitis B virus, and *Mycobacterium tuberculosis*

Figures 2, 3]. There was no significant difference in the plasma TNF-α in the results obtained in *Plasmodium* mono-infection compared with HBV mono-infection ($P > 0.05$; Tables 1, 2 and Figures 2, 3). There was a significant increase in the plasma TNF-α in the results obtained in HBV mono-infection, *M. tuberculosis* mono-infection, and *Plasmodium* spp., compared with the control subjects [$P < 0.05$; Tables 1, 2 and Figure 2]. There was a significant increase in the plasma TNF-α in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and in the controls [$P < 0.05$; Tables 1, 2 and Figures 2, 3].

About 31% (62 of the 200) volunteers were not infected with any of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 16% (32 of 200 volunteers) had co-infections of at least two of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 33% (66 of 200 volunteers) were mono-infected with *Plasmodium* spp.,14% (28 of 200 volunteers) were mono-infected with HBV while 6% (12 of 200 volunteers) were mono-infected with *M. tuberculosis*.

DISCUSSION

This study has been used to compare immunochemical alterations in blood complement 3 (C3), complement 5 (C5), TNF-α, and IL-10 in mono-infections of *Plasmodium* spp., HBV and *M. tuberculosis*.

The results obtained showed that. 69% (138 of the 200 volunteers) were infected with one or more of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 31% (62 of the 200) volunteers were not infected with any of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 16% (32 of 200 volunteers) had co-infections of at least two of *Plasmodium*, HBV, HCV, HIV, and *M. tuberculosis*; 33% (66 of 200 volunteers) were mono-infected with *Plasmodium* spp., 14% (28 of 200 volunteers) were mono-infected with HBV while 6% (12 of 200 volunteers) were mono-infected with *M. tuberculosis*.

The prevalence of 33% *Plasmodium* spp., infection in this study is consistent with the report of Olasunkanmi *et al*.,[16] who reported 31.6%Plasmodium in Abeokuta, Nigeria, among children, This is lower than the report of Okonko *et al*.,[17] that noted a high malaria parasite prevalence rate of 81.5% in genders in Abeokuta, the capital city of Ogun State located in the forest zone of southwestern Nigeria between January 2002 and December 2004.

Musa *et al*.[18] reported the pooled prevalence of HBV in Nigeria between 2000 and 2013 as 13.6% which agrees with 14% HBV infection found in this study.

The WHO[19] reported a rate of 0.52% (521/100,000) for 2010 while Centers for Disease Control and Prevention[20] reported an estimate of 0.22% (219/100,000) for 2016. These rates are lower than 6% *M. tuberculosis* infection reported in this work.

There was a significant increase in the plasma C3 in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection, and in the controls. There was a significant increase in the plasma C3 in the results obtained in *Plasmodium* mono-infection; compared with HBV mono-infection and controls. There was a significant decrease in the plasma C3 in the results obtained in HBV mono-infection compared with the controls. There was a significant increase in the plasma C5 in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and in the controls. There was a significant increase in the plasma C5 in the results obtained in *Plasmodium* mono-infection compared with HBV mono-infection.

There was a significant decrease in the plasma IL-10 in the results obtained in *M. tuberculosis* mono-infection, *Plasmodium* mono-infection, HBV mono-infection compared with the results obtained in the controls.

There was a significant increase in the plasma TNF-α in the results obtained in *Plasmodium* mono-infection compared with the control subjects. There was a significant increase in the plasma TNF-α in the results obtained in HBV mono-infection, *M. tuberculosis* mono-infection, and *Plasmodium* spp., compared with the controls. There was a significant increase in the plasma TNF-α in the results obtained in *M. tuberculosis* mono-infection compared with *Plasmodium* mono-infection; HBV mono-infection and in the controls.

Significant increase in plasma C3, C5, and TNF-α in *M. tuberculosis*, *Plasmodium*, and HBV mono-infections could be explained as follow. *M. tuberculosis* than in *Plasmodium*, HBV mono-infections are triggers that stimulate cleavage of proteases in complement system with their specific proteins for the release of cytokines such as TNF-α which will cause phagocytes to remove foreign and

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damaged cells/materials, bring about inflammation to attract additional phagocytes, and activation of the cell-killing membrane attack complex.[1-3] Complement 3 and 5 level rises in inflammation as part of acute-phase plasma protein response.[6,7] TNF-α is a pro-inflammatory cytokine. It is released in large quantity for instance as a result of infection to induce fever, apoptotic cell death, inflammation, inhibits tumor cell growth including viral replication.[10,11]

A higher plasma values of the complements in *Plasmodium* mono-infection than HBV mono-infection could be attributed to the fact that complements are synthesized in the liver to support antibodies and phagocytic cells to remove pathogens, cause cell death, promote inflammation, and attack pathogen cell membrane. Although *Plasmodium* spp., life cycle involves liver, HBV directly infects liver cells that produce complements. The presence of HBV pm hepatocytes will generate immune responses that cause hepatocellular damage leading to decrease in the synthetic functions of liver including production of complements thereby depleting the plasma concentration of complements such as C3 and C5.[4,5] This explanation also holds for the significant increase in plasma C3 and C5 in *M. tuberculosis* than in *Plasmodium* and HBV mono-infections.

A significant decrease in plasma IL-10 in *M. tuberculosis*, *Plasmodium*, and HBV mono-infections could be related to the immunological functions of IL-10 as an anti-inflammatory cytokine that inhibits the production of pro-inflammatory cytokines such as TNFα but stimulates B cell maturation and antibody production. Increase in plasma TNFα as obtained in this study, can cause overutilization of IL-10 as an anti-inflammatory cytokine as these infections can cause activation of complements to generate inflammation.[12,13]

There was an evidence of host immune responses as evidenced by a significant increase in plasma C3, C5, and TNF-α including a decrease in IL-10 in mono-infections of *Plasmodium* spp., HBV and *M. tuberculosis*.

The above major findings can be associated to the following scientific facts.

Cytokines such as TNF-α and IL-10 play vital roles in host responses to bacterial, viral, and *Plasmodium* infection including immune responses, inflammation, trauma, sepsis, cancer, and reproduction[21-23] as part of the complex biological response of body tissues to harmful stimuli, such as pathogens, damaged cells, or irritants, and is a protective response involving immune cells, blood vessels, and molecular mediators. Inflammation is one of the first immune responses to infection or irritation. Inflammation is a mechanism of innate immunity cytokines modulate the balance between humoral and cell-based immune responses.[24-26] Oxidative stress can induce the release of cytokines. Cytokines are required for fighting off infections and crucial in other immune responses.[27,28] Cytokines and antibody complex has a stronger immunological effect than cytokine alone.[10,29-31]

Immune complements enhance the ability of antibodies to clear pathogens or label them for destruction by other cells.[5,6] Complements are synthesized in the liver by hepatocytes. They trigger the recruitment of inflammatory cells, "tag" pathogens for destruction by other cells by opsonizing, or coating, the surface of the pathogen, form holes in the plasma membrane of the pathogen, resulting in cytolysis of the pathogen cell, causing the death of the pathogen and clear the body of neutralized antigen-antibody complexes.[7-9]

CONCLUSION

This work revealed evidence of host immune responses as evidenced by a significant increase in plasma C3, C5, and TNF-α including a decrease in IL-10 in mono-infections of *Plasmodium* spp., HBV, and *M. tuberculosis*.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Janeway CA Jr., Travers P, Walport M, Shlomchik MJ. The complement system and innate immunity. In: Immunobiology: The Immune System in Health and Disease. New York: Garland Science; 2001. Available from: https://www.ncbi.nlm.nih.gov/books/NBK27100/. [Last retrieved on 2013 Feb 25].
2. Abbas AK, Lichtman AH, Pillai S. Cellular and Molecular Immunology. 6th ed. Pennsylvania, USA: Elsevier; 2010. p. 272-88.
3. Chaplin H Jr. Review: The burgeoning history of the complement system 1888-2005. Immunohematology 2005;21:85-93.
4. Nesargikar PN, Spiller B, Chavez R. The complement system: History, pathways, cascade and inhibitors. Eur J Microbiol Immunol (Bp) 2012;2:103-11.
5. Murphy K, Weaver C. Innate immunity: The first lines of defense. In: Janeway's Immunobiology. 9th ed. New York, USA: Garland Science; 2017. p. 49.
6. de Bruijn MH, Fey GH. Human complement component C3: CDNA coding sequence and derived primary structure. Proc Natl Acad Sci U S A 1985;82:708-12.
7. Abbas AK, Lichtman AH; Pillai S. Effector mechanisms of humoral immunity. In: Basic Immunology: Functions and Disorders of the Immune System. 4th ed., Ch. 8. Philadelphia, PA: Elsevier Saunders; 2012. p. 162.
8. Tack BF, Morris SC, Prahl JW. Fifth component of human complement: Purification from plasma and polypeptide chain structure. Biochemistry 1979;18:1490-7.
9. Fredslund F, Laursen NS, Roversi P, Jenner L, Oliveira CL,

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Pedersen JS, *et al*. Structure of and influence of a tick complement inhibitor on human complement component 5. Nat Immunol 2008;9:753-60.
10. Dowlati Y, Herrmann N, Swardfager W, Liu H, Sham L, Reim EK, *et al*. A meta-analysis of cytokines in major depression. Biol Psychiatry 2010;67:446-57.
11. Victor FC, Gottlieb AB. TNF-alpha and apoptosis: Implications for the pathogenesis and treatment of psoriasis. J Drugs Dermatol 2002;1:264-75.
12. Eskdale J, Kube D, Tesch H, Gallagher G. Mapping of the human IL10 gene and further characterization of the 5′ flanking sequence. Immunogenetics 1997;46:120-8.
13. Mosser DM, Zhang X. Interleukin-10: New perspectives on an old cytokine. Immunol Rev 2008;226:205-18.
14. Cheesebrough M, editors. District Laboratory Practice in Tropical Countries. Part 1. New York, USA: Cambridge University Press; 2002.
15. Spring KR, Davidson MW. "Introduction to Fluorescence Microscopy". Nikon Microscopy U; 2008. Available from: https://en.wikibooks.org/wiki/Chemical_Sciences: _A_Manual_for_CSIR-UGC_National_Eligibility_Test_for_Lectureship_and_JRF/Fluorescence_microscope. [Last retrieved on 2008 Sep 28].
16. Olasunkanmi OI, Akingbade OA, Akinjinmi AA, Okerentugba PO, Onajobi IB, Okonko IO. Prevalence of malaria Plasmodium among children in Abeokuta, Nigeria. Acad Arena 2013;5:44-7. Available from: http://www.sciencepub.net/academia. [Last accessed on 2013 Sep 30].
17. Okonko IO, Soleye FA, Amusan TA, Ogun AA, Udeze AO, Nkang AO, *et al*. Prevalence of malaria *Plasmodium* in Abeokuta, Nigeria. Malays J Microbiol 2009;5:113-8.
18. Musa BM, Bussell S, Borodo MM, Samaila AA, Femi OL. Prevalence of hepatitis B virus infection in Nigeria, 2000-2013: A systematic review and meta-analysis. Niger J Clin Pract 2015;18:163-72.
19. WHO Tuberculosis Prevalence Survey, Nigeria; 2010. Available from: http://www.who.int/tb/advisory_bodies/impact_measurement_taskforce/meetings/prevalence_survey/15_16oct09_nigeria_bottlenecks_in_survey_preparation.pdf. [Last accessed on 2019 May 20].
20. Centers for Disease Control and Prevention; 2018. Available from: https://www.cdc.gov/globalhivtb/where-we-work/nigeria/nigeria.html. [Last accessed on 2019 Aug 30].
21. Chokkalingam V, Tel J, Wimmers F, Liu X, Semenov S, Thiele J, *et al*. Probing cellular heterogeneity in cytokine-secreting immune cells using droplet-based microfluidics. Lab Chip 2013;13:4740-4.
22. Carpenter LR, Moy JN, Roebuck KA. Respiratory syncytial virus and TNF alpha induction of chemokine gene expression involves differential activation of Rel A and NF-kappa B1. BMC Infect Dis 2002;2:5.
23. Tian B, Nowak DE, Brasier AR. A TNF-induced gene expression program under oscillatory NF-kappaB control. BMC Genomics 2005;6:137.
24. Zhang JM, An J. Cytokines, inflammation, and pain. Int Anesthesiol Clin 2007;45:27-37.
25. Gaffen SL. Structure and signalling in the IL-17 receptor family. Nat Rev Immunol 2009;9:556-67.
26. Said EA, Dupuy FP, Trautmann L, Zhang Y, Shi Y, El-Far M, *et al*. Programmed death-1-induced interleukin-10 production by monocytes impairs CD4+ T cell activation during HIV infection. Nat Med 2010;16:452-9.
27. James W, Berger T, Elston D. Andrews' Diseases of the Skin: Clinical Dermatology. 10th ed. Pennsylvania, USA: Saunders; 2005.
28. Saito S. Cytokine cross-talk between mother and the embryo/placenta. J Reprod Immunol 2001;52:15-33.
29. Chen HF, Shew JY, Ho HN, Hsu WL, Yang YS. Expression of leukemia inhibitory factor and its receptor in preimplantation embryos. Fertil Steril 1999;72:713-9.
30. Dinarello CA. Proinflammatory cytokines. Chest 2000;118:503-8.
31. Zhu H, Wang Z, Yu J, Yang X, He F, Liu Z, *et al*. Role and mechanisms of cytokines in the secondary brain injury after intracerebral hemorrhage. Prog Neurobiol 2019;178:101610.