African Journal of Biology and Medical Research
ISSN: 2689-534X
Volume 7, Issue 2, 2024 (pp. 187-197)
www.abjournals.org

# MALARIA AND TYPHOID CO-INFECTION AMONG CHILDREN UNDER 5 YEARS OF AGE AT CHUKWUEMEKA ODUMEGWU OJUKWU UNIVERSITY TEACHING HOSPITAL, AWKA, ANAMBRA STATE, NIGERIA

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**Cite this article:**

Okeke O. A., Nwabumere S. M., Nwadike C. C., Udeh P. N., Ishar C. O., Uchenna A. U., Imakwu C. A. (2024), Malaria and Typhoid Co-Infection among Children under 5 Years of Age at Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Awka, Anambra State, Nigeria. African Journal of Biology and Medical Research 7(2), 187-197. DOI: 10.52589/AJBMR-W3OXPZO4

**Manuscript History**

Received: 12 Mar 2024

Accepted: 22 May 2024

Published: 24 Jun 2024



**ABSTRACT:** *This study sheds light on the prevalence of malaria and typhoid in children below the age of five in a hospital in Nigeria. This study aimed to determine the presence of malaria, typhoid and malaria-typhoid co-infection in children less than five years of age. In this community-based descriptive, quantitative and cross-sectional hospital-based survey, the blood samples of 125 children between 0 to less than 5 years (68 males and 57 females) were examined for the presence of malaria parasites and typhoid infection. Blood samples were collected using venepuncture. The malaria parasitaemia was detected using malaria microscopy on a thick blood film. Typhoid fever infection was detected using the Widal Agglutination Test. The chi-square test was used to compare the prevalence of malaria, typhoid fever and malaria/typhoid co-infections between male and female infected and uninfected participants and between children below 1 year and those 1 year and above. P-values less than 0.05 were considered significant. A prevalence of 47.2%, 32% and 16% were recorded for malaria, typhoid and malaria/typhoid co-infection respectively. A mean malaria parasite intensity of 56.8475 (±3.30177) was recorded. There was no significant difference between the prevalence of malaria, typhoid and malaria/typhoid co-infection between the genders and age groups. Also, there was no significant difference between the mean PCV of the infected (33.1610 (±0.80748) and uninfected (34.6667 (0.48441) (P> 0.05). These results underscore the importance of continued efforts to combat these diseases and improve the health and well-being of children in the region.*

**KEYWORD:** Malaria, Typhoid, Co–infection, Children less than 5 years of age, Hospital, Awka, Anambra State, Nigeria.



Article DOI: 10.52589/AJBMR-W3OXPZO4
DOI URL: https://doi.org/10.52589/AJBMR-W3OXPZO4

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www.abjournals.org

## INTRODUCTION

Malaria, also known as Plasmodiasis, is a severe disease caused by *Plasmodium* sp. These parasites are obligate intracellular organisms that depend on red blood cells for survival. They are transmitted to humans through the bite of infected female *Anopheles* mosquitoes. Once in the bloodstream, they migrate to the liver cells (hepatocytes) and then spread throughout the body via the circulatory system, affecting various organs of the vertebrate host (Centers for Disease Control and Prevention (CDC), 2020). Three major *Anopheles* species transmit malaria in man: *Anopheles gambiae, Anopheles funestus* and *Anopheles arabiense.* The most important of these is *A. gambiae.* This is because the female *A. gambiae,* aside from needing blood meals for the development of its eggs, prefers human blood to the blood of other vertebrates (Harrison *et al*., 2021).

There are four major species of *Plasmodium* known to transmit malaria in man: *Plasmodium falciparum, Plasmodium ovale, Plasmodium vivax, and Plasmodium malariae.* Two of these species (*P. falciparum* and *P. vivax*) pose the greatest threat. *P. falciparum* is the deadliest malaria parasite and the most prevalent in Africa. *P. vivax* is the dominant malaria parasite in most countries outside of Sub-Saharan Africa (CDC, 2022). There is also a fifth species, *Plasmodium knowlesi,* a parasite that naturally infects macaque monkeys that have been severally reported in man in Asian countries, particularly Malaysia and Indonesia and as such, is considered a zoonotic infection (CDC, 2022). Of all these five species, *P. falciparum* is the most virulent, which causes malignant tertian malaria (Zekar *et al*., 2023). It brings about a lot of complications, such as cerebral malaria, acute renal failure, dehydration, gastrointestinal symptoms, severe anaemia, pernicious anaemia, hyperpyrexia, pulmonary, oedema and hypoglycaemia (CDC, 2020). Some patients may be asymptomatic, while others may have mild or severe symptoms. It may take from 9 to 40 days for symptoms to appear. Early symptoms can include fever, nausea, vomiting, fatigue, chills, headaches, muscle aches, cough and sweating (CDC, 2022; World Health Organization WHO, 2022). Malaria may cause anaemia and jaundice (yellowing of the eyes). If not treated within 24 hours, the disease can worsen, leading to seizures, impairment of brain and spinal cord function, kidney failure, seizures, mental confusion, loss of consciousness, coma and death (CDC, 2022; WHO, 2022).

In endemic areas, children under the age of 5 frequently experience recurrent and severe malaria episodes. Following recovery, they may develop partial immunity. Consequently, older children and adults often carry the malaria parasites in their bloodstream without displaying any clinical symptoms, a condition known as asymptomatic parasitemia. Notably, the majority of malaria-related deaths occur in children under 5 years of age (Parang, 2020). Recurrent malaria episodes in this age group can result in chronic anaemia, malnutrition, and impaired growth (Parang, 2020). Children with severe malaria may have poor outcomes such as acidosis, seizures, decreased cognitive function, and impaired kidney function, with worsened effects if they have pre-existing chronic conditions (Ssemata *et al.*, 2023). Indicators such as hyperparasitaemia (high levels of parasites in the blood), respiratory difficulty, young age, severe anaemia, and hypoglycaemia are associated with unfavourable outcomes (https://www.cdc.gov/malaria/about/disease.html). The presence of *P. falciparum* leads to the accumulation of red blood cells in the microvasculature (small blood vessels) of the brain and other organs (Trivedi & Chakravarty, 2022). Seizures and comas are prevalent in paediatric malaria cases (Song *et al.*, 2022). In non-immune children with a significant parasitic load in their bloodstream, the occurrence of generalised bleeding is


Article DOI: 10.52589/AJBMR-W3OXPZO4
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occasionally observed attributed to disseminated intravascular coagulation, which may be linked to a bacterial infection in some cases (Costell & Nehring, 2022). Factors contributing to its severity in Africa include the efficiency of the *A. gambiae* mosquito as a vector, the predominance of the highly pathogenic *P. falciparum* parasite, limited resources and unstable socio-economic conditions hindering malaria control efforts (WHO, 2020; CDC, 2022).

Typhoid fever, caused by *Salmonella typhi*, is a bacterial infection. Although other *Salmonella* serotypes can cause similar syndromes, they generally result in less severe disease (Bhandari *et al*., 2022; WHO, 2023). Children are at a higher risk of typhoid fever, but their symptoms are typically milder compared to adults (National Health Service, 2021). The coexistence of malaria and typhoid fever increases the risk of misdiagnosis and mistreatment due to their similar clinical presentations (Odikamnoro *et al.*, 2018; Zerfu *et al*., 2018). It can also lead to severe complications such as maternal and childhood anaemia, persistent fever, and even mortality (Zerfu *et al.*, 2018). Most often the possibility of these two infections co – infecting a child is not envisaged in childhood febrile illnesses. Therefore, this study investigated the co-infection of malaria and typhoid in children less than 5 years of age in a tertiary hospital in Awka, Anambra State.

## MATERIAL AND METHODS

### Study Site

The study was carried out on children who presented with febrile illness at Chukwuemeka Odumegwu Ojukwu University Teaching Hospital [COOUTH], Amaku, Awka, Anambra State. This was done from September 2023 to November 2023.

### Study Design

Community-based descriptive, quantitative and cross-sectional hospital survey was adopted.

### Sample Size Calculation and Sample Size

The sample size was calculated using the WHO method of sample size calculation:

$n = Z^2_{1-\alpha/2}\ P\ (1-P)/d^2$

Where: n signifies the sample size; $Z^2_{1-\alpha/2}$ signifies the standard normal variate (at 5% type I error =1.96 (P<0.005). P ((20%) signifies the expected proportion in the population based on previous studies or pilot studies, d signifies absolute error or precision (using 7% and at type I error of 7%). Therefore,

$n = 1.962 \times 0.20\ (1-0.20)/0.07^2$

$n = 3.8416 \times 0.20\ (0.8)/0.0049$

$n = 0.76832 \times 0.8/0.0049$

$n = 0.614656/0.0049$

$n = 125.44.$


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One hundred and twenty-five **(**125) patients (68 males and 57 females) were sampled from the population.

**Inclusion Criteria**

1. Children presenting with febrile illness at the paediatric outpatient clinic.
2. Both male and female children.
3. Aged 0 to less than 5 years.
4. Children who have not received malaria treatment in the past two weeks.
5. Children whose mother/caregiver signed the consent form

**Exclusion Criteria**

1. Children who are already admitted to the hospital.
2. Children above 5 years of age.
3. Children whose mother/caregiver did not sign the consent form.
4. Children who are suffering from sickle cell disease.

**Procedure Methodology**

A blood sample was collected by venule puncture, using a 2ml syringe. A portion of it was used for microscopy examination. Another portion was transferred into a capillary tube for packed cell volume analysis, while the rest were transferred into an EDTA blood container for Widal analysis.

For microscopy thick and thin smears of blood were made on a clean, grease-free glass slide according to WHO (2016) standards. The Widal Agglutination Test was performed on all blood samples using the rapid slide titration method by Georges-Fernand Widal and edited by Prashant(2022) to detect *Salmonella* antigens; somatic (O) and flagella (H). The manufacturer's instructions of an antibody titre of ≥1:160 were considered significant and suggestive of infection was strictly adhered to.

**Data Analysis**

Analysis of data was done using SPSS Version 25.0. The chi-square test was used to compare the prevalence of malaria, typhoid fever and malaria/typhoid co-infections between male and female participants and between children less than 1 year and those 1 year and above. A P-value less than 0.05 was considered significant.

**Ethical Approval**

A certificate of ethical approval (COOUTH/CMAC/ETH.C/Vol.1/FN 04/273) was obtained from the Research and Ethics Committee of Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Amaku, Awka, Anambra State.


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www.abjournals.org

## RESULTS

Blood samples collected were examined for the presence of malaria, typhoid and malaria/typhoid co-infection about age group and gender. The PCV was also determined for both infected and uninfected participants. Out of the 125 participants, 68 (54.4%) were males, while 57 (45.6%) were females.Table number 1 shows the prevalence of malaria in the study group. The overall prevalence recorded was 58(47.2%), 31 (45.59%) of the males tested positive, while 37 (54.41%) tested negative. Similarly 28 (49.12%) of the females tested positive, while 29 (50.88%) tested negative. The chi-square test showed that there was no significant difference between the prevalence of malaria in male and female participants ($p > 0.05$). Therefore, the prevalence of malaria infection in the study area is not gender-sensitive.

The age group analysis showed that 31 (24.8%) out of the 125 children examined were below 1 year of age, while 94 (75.2%) were 1 year and above. Out of the 31 children below 1 year of age, 16 (51.613%) tested positive for the malaria parasite, while 15 (48.387%) tested negative for the infection. Of the 94 children 1 year and above, 43 (45.745%) tested positive, while 51 (54.255%) tested negative. There was no significant difference between the prevalence of malaria in children below 1 year of age and those 1 year and above, the malaria parasite infection in the age group is not age-biassed.

**Table 1: Prevalence of Malaria by Gender and Age Group**

| | Tested (%) | Infected (%) | Uninfected (%) | P-value |
|---|---|---|---|---|
| **Sex** | | | | 0.693 |
| Male | 68 (54.4%) | 31 (45.588%) | 37 (54.412%) | |
| Female | 57 (45.6%) | 28 (49.123%) | 29 (50.877%) | |
| **Age group(years)** | | | | 0.571 |
| < 1 year | 31 (24.8%) | 16 (51.613 %) | 15 (48.387%) | |
| ≥ 1 year | 94(75.2%) | 43 (45.745%) | 51(54.255%) | |
| **Total** | 125 | 59 (47.2%) | 66(52.8%) | |

Table number 2 shows that the total mean intensity of the malaria parasite-infected children was 56.8475 ±3.30177. The males had a mean intensity of 58.6452 ±4.67608, while the females had a mean intensity of 54.8571 ±4.70835. There was no significant difference between the mean intensity of the infected males and females ($p > 0.05$).

Also, children below 1 year had a mean parasite intensity of 62.6667 ±6.23100, while those 1 year and above had a mean parasite intensity of 55.6744 ±3.88280, there was equally no significant difference between the mean intensity of the children below 1 year of age and those 1 year and above ($p > 0.05$). Therefore, the malaria parasite intensity amongst the infected children is neither gender or age-sensitive in the study area.


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**Table 2: Malaria Mean Parasite Intensity of Infected Children by Gender and Age Group**

| Gender | Infected | Mean number of parasites | P-value |
|---|---|---|---|
| Male | 31 | 58.6452 ±4.67608 | 0.571 |
| Female | 28 | 54.8571 ±4.70835 | |
| **Age group(years)** | | | 0.358 |
| < 1 year | 16 | 62.6667 ±6.23100 | |
| ≥ 1 year | 43 | 55.6744 ±3.88280 | |
| Total | 59 | 56.8475 ±3.30177 | |

In Table number 3, the mean PCV of the infected children was 33.1610 ±0.80748, while that of the uninfected children was 34.6667 ±0.48441. T-test showed that there was no significant difference between the PCV of the infected and uninfected children (p> 0.05),

**Table 3: Mean PCV of Malaria Infected and Uninfected Children**

| Malaria parasite test result | Number | Mean PCV |
|---|---|---|
| Positive | 59 | 33.1610 ±0.80748 |
| Negative | 66 | 34.6667±0.48441 |
| **P-value** | 0.113 | |

Table number 4 shows that the total prevalence of typhoid fever recorded was 40(32%), 24(35.294%) of the males tested positive for typhoid fever, while 44 (64.706%) tested negative and 16 (28.070%) females tested positive for typhoid fever, while 41(71.9298%) tested negative. The chi-square test showed that there was no significant difference between the prevalence of typhoid fever in male and female participants (p> 0.05).

In the age group prevalence, 8(25.806%) of children less than 1 year of age tested positive for typhoid fever, 23 (74.194%) tested negative, 32 (33.043%) of children one year and above tested positive for typhoid fever, while 62 (65.957%) tested negative. There was no significant difference between the prevalence of typhoid between children below 1 year and those 1 year and above (p > 0.05).

**Table 4: Prevalence of Typhoid Fever by Gender and Age Group among Children Aged Less than Five Years**

| | Tested (%) | Positive (%) | Negative (%) | P-value |
|---|---|---|---|---|
| **Gender** | | | | 0.388 |
| Male | 68 (54.4%) | 24 (35.294%) | 44 (64.706%) | |
| Female | 57 (45.6%) | 16 (28.070%) | 41 (71.9298%) | |
| **Age group (years)** | | | | 0.394 |
| < 1 year | 31 (24.8%) | 8 (25.806 %) | 23 (74.194%) | |
| ≥ 1 year | 94(75.2%) | 32 (34.043%) | 62 (65.957%) | |


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| | | | |
|---|---|---|---|
| **Total** | 125 | 40 (32%) | 85 (68%) |

Table number 5 shows that a co-infection rate of 20 (16%) was recorded, 12 (17.647%) tested positive for malaria and typhoid fever co-infection while 56 (82.353%) tested negative. Out of the 57 females, 8 (14.035%) tested positive for malaria and typhoid co-infection while 49 (85.965%) tested negative, there was no significant difference between the malaria/typhoid co-infection rate in both male and female participants ($p > 0.05$).

Age group results showed that among children less than 1 year, 3 (2.4%) tested positive for malaria and typhoid co-infection, while 28 (22.4%) tested negative, while in children 1 year and above 17 (13.6%) tested positive for malaria and typhoid co-infection, while 28 (22.4%) tested negative. There was no significant difference between the co-infection rate of the under 1 children and those 1 year and above ($p > 0.05$).

**Table 5: The Rate of Malaria and Typhoid Co-infection by Gender and Age Group**

| | **Tested (%)** | **Positive (%)** | **Negative (%)** | **P-value** |
|---|---|---|---|---|
| **Gender** | | | | 0.583 |
| Male | 68 (54.4%) | 12 (17.647%) | 56 (82.353%) | |
| Female | 57 (45.6%) | 8 (14.035%) | 49 (85.965%) | |
| **Age group (years)** | | | | 0.268 |
| < 1 year | 31 (24.8%) | 3(2.4%) | 28 (22.4%) | |
| ≥ 1 year | 94 (75.2%) | 17(13.6%) | 77(61.6%) | |
| **Total** | 125 | 20 (16%) | 105 (84%) | |

## DISCUSSIONS

The study investigated the rate of malaria and typhoid co-infection among children less than 5 years of age attending Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Awka, Anambra State, Nigeria. A high prevalence of malaria was recorded among children below 5 years of age. The result of this study was lower than that of Babalola *et al. (2020)* who reported a 70% prevalence of malaria in children less than five years of age in Igabi LGA, Kaduna, Nigeria, however, it is higher than that recorded by Odikamnoro *et al. (2018)* that recorded a prevalence of 34.2% in children in Unwana Community, Afikpo North Local Government Area, Ebonyi State, South-eastern Nigeria. Equally, Nwaneli *et al. (*2020) reported a lower prevalence of 16.7% in children below five years of age in another community in South-East Nigeria. The high prevalence recorded in the study could be attributed to several factors such as poor use of insecticide-treated bed nets by parents and guardians of the children, poor sanitation, poor drainage and most importantly, the fact that their immune system is not yet fully developed which makes them highly susceptible to malaria infection.

The prevalence of malaria was not gender sensitive in this study. Egbom *et al. (*2022) had a similar result in Rivers State, Nigeria. There was no significant difference in malaria prevalence rate between males and females under 5 years ($P = 0.156$) (Nwaneli *et al.*,


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2020). This indicates that both sexes were equally exposed to the infection in the same environment.

Also, children less than 1 year of age had a higher percentage malaria prevalence 1 year and above without a significant difference. This shows that malaria was evenly distributed between the two age groups studied. This could be a result of the fact that the children were exposed to similar environmental conditions. In a study carried out by Obasohan *et al.* (2021), among children 6 – 59 months in Nigeria the overall proportion of children 6–59 months of age that had malaria fever positive as assessed by RDTs was 35.5% (3418/10,185), (CI: 33.9–37.1). Kebbi State had 77.7%, (CI: 70.2–83.5), which was the highest proportion of 6–59 months who were malaria positive, next in line was Katsina State with 55.5%, (CI: 47.7–63.1). The Federal Capital Territory (FCT) Abuja had a proportion of 29.6%, (CI: 21.6–39.0), malaria-positive children of 6–59 months of age. Children between the ages of 48 and 59 months were 2.68 times more likely to have malaria fever than children of ages 6–11 months (AOR = 2.68, 95% CI: 2.03–3.54). Similarly, in Southeast Nigeria, Nwaneli *et al.* (2020) reported that the malaria prevalence rate was 16.7% in children < 5 years and they were more prone to higher parasite density.

In this study, the infected children had high mean parasite intensity. The high intensity of the malaria parasite could be a result of the children's underdeveloped immune system which has made them highly susceptible to malaria and made it easy for *Plasmodium* to thrive and multiply. Ezenwelu (2016) reported an increasing burden of malaria in the early years of many children in Abuja. Equally, the results of the study revealed that the parasite intensity of the males was slightly higher than that of the females, but the differences were not significantly different. This shows that gender did not affect the parasite intensity of the children. At Jos University Teaching Hospital, Nigeria eighteen (18) per cent of the study population had mean parasite densities higher than the critical value of 10,000 per microlitre. There was no difference in parasitaemia about gender (Ikeh *et al*., 2005).

The parasite intensity was not determined by the age of the participants. However, children below 1 year of age had mean parasite intensity slightly higher than that of 1 year and above. This result is in line with the conclusion of Ranjha *et al.* (2023) that the younger age group is vulnerable to severe malaria due to an immature immune system. A weak relationship was found to exist between the density of parasitaemia and the ages of children infected with malaria parasites in Port Harcourt, Southern Nigeria (Atoukaritou *et al*., 2032).

The mean Packed Cell Volume (PCV) of the infected children is slightly lower in this study but no statistically significant difference was observed. Okeke *et al. (2020)* reported a similar result among children of the same age group in Anambra State, Nigeria. A statistically significant difference was reported by Atoukaritou *et al.* (2032). This could be as a result of the fact that the infected children were well fed which may have counteracted the effect of the invasion of the red blood cells by the malaria parasite.

There was a high percentage of typhoid infection in the studied group. This is in line with the study done by Igiri *et al. (2018)* which recorded a typhoid fever prevalence of 33.3%. However, the result obtained from this study is higher than the result from Odikamnoro *et al.* (2018) who reported a typhoid prevalence of 13.1% in children in Southeastern Nigeria. The prevalence in the males was slightly higher than that of the females. However, there is no significant difference between typhoid prevalence in male and female


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children. This shows that age did not affect the prevalence of typhoid in the children studied. This is in line with the study done by Igiri *et al.* (2018) which showed a slightly higher prevalence in males than in females.

Based on age group, the typhoid prevalence was slightly higher in children 1 year and above, but the difference was not significant. This shows that the typhoid infection was evenly distributed between the two age groups studied. According to Sinha *et al*. (1999), typhoid is a common and significant cause of morbidity between 1 and 5 years of age. They argued that the incidence rate of typhoid per 1000 person-years was 27.3 for ages under 5 years.

The total malaria and typhoid co-infection rate of the 125 children studied was low. Odikamnoro *et al. (2018)* recorded a higher rate in. Also, Nakisuyi (2023) reported a low malaria-typhoid co-infection in children in Western Uganda. Reed *et al*. (1994) opined that typhoid fever occurs in children less than 2 years of age but is thought to be a mild, often unrecognised illness.

The males had a co-infection rate slightly higher than that of the females without significant difference ($p>0.005$). This shows that gender had no significant effect on the co-infection of typhoid and malaria. Odikamnoro *et al.* (2018) also recorded a slightly higher malaria/typhoid co-infection rate in females than in males. In Ngaoundéré (Adamawa, Cameroon), Sohanang *et al.* (2023) reported that the female group and children from 2 to 10 years old were the most affected groups by the two infectious agents.

Children within the age range of less than 1 recorded a co-infection rate lower than that of children 1 year and above; however, there is no significant difference ($p>0.005$). Malaria, typhoid and co-infections were found to be neither gender nor age-group-sensitive in the study area. In a Rural Health Center in Northwest Ethiopia, 2–5-year-old children and poor hand-washing habits were significantly associated with malaria and typhoid infection, respectively (Birhanie *et al*., 2014). The use of only the Widal test may have affected the prevalence.

## CONCLUSION

Even though there was a high prevalence of malaria among the studied age group, the rate of malaria/typhoid co-infection was low in children less than 5 years in Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Amaku, Awka Anambra State with malaria having a higher prevalence than typhoid.

## RECOMMENDATIONS

To ensure optimal diagnosis and treatment of children with febrile symptoms, it is generally advised to conduct both malaria parasite and typhoid tests. By doing so, we can avoid the risks of over or under-treatment, misuse of antibiotics, and the possibility of developing resistance to antimalarials and antibiotics. For a comprehensive assessment of a child's febrile illness, it is recommended that they undergo a comprehensive test to detect malaria and any other co-infecting diseases.


Article DOI: 10.52589/AJBMR-W3OXPZO4
DOI URL: https://doi.org/10.52589/AJBMR-W3OXPZO4

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