Relationship between Malaria Parasitaemia and Socio-demographic and Environmental Risk Factors among Under-five Children in Maiduguri, Borno State, Nigeria

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Abstract

Background: *Plasmodium falciparum* is one among other species responsible for malaria in Nigeria. This study determined the relationship between the malaria infection status of children under the age of 5 years in Maiduguri, Borno State and selected demographic and environmental factors to identify significant risk factors associated with malaria infection.

Methods: A cross-sectional study design was used and blood samples were collected from all the children that met the eligibility criteria for the study and subjected to microscopy for the detection of *P. falciparum* parasitaemia. Additionally, a closed-ended questionnaire was administered to ascertain the risk factors associated with the infection. Data was analysed using Statistical Products and Service Solution version 20.0. Chi-square and regression analyses were used to test for association between socio-demographic and environmental risk factors, and malaria parasitaemia. A $p < 0.05$ was considered statistically significant at 95% confidence interval.

Results: The prevalence of *P. falciparum* parasitaemia in under-five-year-old children was 156 (43.0%): 38.9% in males and 49.0% in females. The odds of malaria infection were high among all age groups of parents/guardians. Factors such as gender and hospitals were observed to be the predictors of malaria infection in children.

Conclusion: Sociodemographic and environmental factors such as gender and hospitals respectively were the predictors of malaria infection in under 5 years children in Maiduguri, Borno State, Nigeria.

Keywords: Malaria, *Plasmodium falciparum* parasite, Risk factors, Nigeria

Introduction

Malaria is a disease of global public health importance and a leading cause of mortality and morbidity in children in sub-Saharan Africa.[1] Children account for 67% of all global malaria deaths compared to other age groups.[2] According to the World Health Organization, in 2022, almost 90% of the global burden of malaria was in Africa, and Nigeria had the largest burden due to its large human population.[3] The persistent malaria epidemic across many countries in Africa is due to cultural, social and environmental factors that are unique to these countries which are more often than not ignored in the design and implementation of intervention programmes against malaria.[4]

For interventions to succeed, there is a need to focus on the fundamental risk factors of malaria by addressing the behavioural, socio-cultural and environmental dimensions of risks that drive the malaria epidemic.[5,6] Over the years, several control measures such as Long Lasting Insecticidal Nets (LLINs) and antimalarial drugs have been implemented to reduce the number of malaria cases in children under 5 years.[2] More effective implementation of these control measures requires a deeper understanding of the epidemiology and risk factors associated with the disease.[7]

A wide variety of risk factors such as age, gender and region of residence have been identified as possible predictors of malaria infection. In the same manner, environmental factors such as buildings, socioeconomic factors such as educational level, economic status, and employment have been identified as risk factors for malaria infection.[8,9] There is still a need to identify the influence of these factors in a local context for the successful malaria control programme. Therefore, this study was undertaken to investigate the relationship between malaria parasitaemia in children under the age of 5 years and some demographic and environmental risk factors in Maiduguri, Nigeria.

Methodology

Study area

Maiduguri, the Capital of Borno State, lies on latitude 11^0 40'N and longitude 13^{0}5E[10]. It is located in the Sahel Savannah region of northeast Nigeria, with annual rainfall and temperature of about 650 mm and 32^{o}C respectively. March and April are the hottest periods of the year with temperatures ranging between 30^{o}C to 40^{o}C. It is usually cold and dry during the harmattan, with November to January being the coldest months[11]. The study was carried out at the Paediatrics Out Patient Departments (POPDs), General Outpatient Departments (GOPDs) and Paediatrics wards of University of Maiduguri Teaching Hospital (UMTH), State Specialist Hospital Maiduguri (SSHM), Umaru Shehu Ultramodern Hospital (USUMH) and Mohammed Shuwa Memorial Hospital Maiduguri (MSMH) Borno State.

Study population

The population for the study comprised of under five-year children on admission as well as outpatients in the GOPDs and POPDs of the selected hospitals in Maiduguri, Borno State, Nigeria.

Study design and sample size

The study used a cross-sectional descriptive study design. Children less than five years were selected from the study hospitals to determine the prevalence of malaria parasitaemia in the population and the associated risk factors.

The sample size was determined using the formular[12]:

$$n = (Z_{\alpha/2})^2 * p(1 - p)/MOE^2$$

where $Z_{\alpha/2}$ is the critical value of the normal distribution at 95% confidence level, n = minimum sample size and the margin of error (MOE) = 0.05.

$n = (1.96)^2 * 0.5 (1 - 0.5) / (0.05)^2$

$= 3.84 * 0.5 \ (1 - 0.5) / 0.25$

$n = 384$

Sampling technique

Three hundred and eighty-four children within the age range of (6-59 months) were enrolled in this study. The children were selected by simple random sampling technique by balloting using the lists of children on admission or in the OPD as the case may be.

Data collection

A closed-ended questionnaire was developed by the researchers for the purpose of data collection. The questionnaire comprised two parts, the democraphic information of the respondents as well the parameters associated with the environmental risk factors for malaria. The questionnaire was pretested on children of the same age group in Yerwa and Gwange clinics in Maiduguri using 10% of sample size. The data for the research were collected from November 2021 to June 2022 from the four selected hospitals.

Collection of venous blood by venipuncture

Blood samples were collected as was previously described.[13] Collection tubes were pre-cleaned and the slides were labelled with the patient's name, date and time of collection. The slides were cleaned with alcohol and allowed to dry. The venous blood was collected in a vacuum tube containing anticoagulant (EDTA) and transferred into a bottle with EDTA and mixed well. Two thick smears and 2 thin smears were immediately prepared after collection.

Staining of blood films

Thick blood film was stained following the procedure documented by previous researchers.[13]

Procedures of malaria parasites identification

The laboratory procedures used for malaria parasite identification were previously described.[14]

Data analysis

Data obtained were subjected to descriptive statistics. Logistic regression and Chi-square analyses were conducted using Statistical Products and Service Solution (IBM-SPSS version 20.0.) with p = 0.05 considered statistically significant at 95% confidence interval.

Ethical Clearance

Before the commencement of the fieldwork, ethical clearance ("ADM/TH/497/Vol.1", "SSHGEN/641/Vol.1", "MSMH/NHS/122/Vol.1", "USUMH/172/Vol.1") was obtained from the Ethical Committees of University of Maiduguri Teaching Hospital Maiduguri, State Specialist Hospital Maiduguri, Mamman Shuwa Memorial Hospital Maiduguri and Umaru Shehu Ultramodern Hospital Maiduguri, respectively to carry out the research. The parents/guardians consented in writing before the commencement of the study. Detailed explanation about the study was given to the parents and were informed that their participation in the study was purely voluntary. All the risks were explained to them. They were told that they may not gain materially from the study but if, based on the result of this study, malaria is controlled in Maiduguri, they would gain indirectly through a malaria free society.

Results

Table 1 shows that of the 384 questionnaires distributed to all the eligible parents/guardians and their children/wards, 363 were correctly completed giving a response rate of 94.5%. The overall prevalence of malaria parasitaemia in the children was 43%. There was a statistically significant association between malaria parasitaemia and gender as females recorded a higher prevalence (72/147; 49.0%) than males (84/216; 38.9%, p = 0.05). Majority of the parents; 198 (54.5%) had tertiary education, while 39 (10.7%) had primary education but the association between malaria infection status and the educational levels of the parents/guardians was not statistically significant (p = 0.420).

Table 2 shows a lower prevalence of malaria among respondents in rural areas (79/187; 42.2%) compared to those in urban areas (77/176; 43.8%).There was, however, no statistically significant association between malaria status and the district of residence of the respondents (p = 0.77). Further more, the association between malaria infection and the wall and floor materials for dwelling was not statistically significant (p = 0.66 and p = 0.84 respectively). The majority of the respondents; 221 (60.9%) used ceramics, while the least number used floor; 4 (1.1%). Sixty-one (64.9%) of the children who attended SSHM had malaria infection followed by 34 (31.9%) of those who attended USUMH with a significant association between the hospital attended and malaria prevalence (p = 0.00). Moreover, the result shows that 119 (32.8%) of the respondents sprayed insecticides in their dwellings in the last 12 months, while 138 (38.0%) of the respondents did not spray insecticides in the last 12 months.

The odds of malaria infection were higher among children whose parent/guardians were aged between 48-57 years (OR = 1.41, 95% CI:0.62-3.16, $p > 0.05$).The risk of parasitaemia increased by 65% (OR = 1.65, 95% CI:0.83-3.29, $p > 0.05$) among children whose parents attended only primary school compared to those whose parents attended tertiary education. The association between malaria infection and marital status of the parents/guardians of the children was also not significant, as children whose parents were divorced recorded the highest odd ratio (OR =0.73, 95% CI:0.15-3.47, $p > 0.05$). Likewise, the risk of malaria infection was higher (OR = 1.82, 95% CI:0.57-3.39, $p > 0.05$) among those parents/guardians that had other businesses apart from farming, public service and retirees.

Additionally, the study area (OR=2.95, 95% CI:1.60-5.43, $p < 0.05$) was strongly associated with a high risk of malaria infection in under five children. But dwellings sprayed with insecticides in the last 12 months (OR = 1.07, 95% CI:0.63-1.81, $p < 0.05$), main wall materials for dwelling (OR = 1.08, 95% CI:0.42-2.77, $p > 0.05$), and the floor materials for dwelling (OR = 2.67, 95% CI:0.19-36.76, $p > 0.05$) were not associated with a risk of malaria in under children. (Table 4)

Table 1: Association of malaria in children with socio -demographic characteristics (n = 363)

Variable/ Category	Positiven (%)	Negative n (%)	Total n(%)	χ^2	p-value
Age of the Parents/Guardian (in Years)					
18-27	33 (41.3)	47 (58.8)	80 (22.0)		
28-37	37 (40.2)	55 (59.8)	92 (25.3)	1.	
38-47	38 (45.2)	45 (53.6)	84 (23.1)	48	
48-57	34 (46.6)	39 (53.4)	73 (20.1)	9[a]	0.829
More than 57	13 (38.2)	21 (61.8)	34 (9.3)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Gender of the children					
Male	84 (38.9)	132 (61.1)	216 (59.5)	3.	
Female	72 (49.0)	75 (51.0)	147 (40.5)	63	0.050
Total	156 (43.0)	207 (57.0)	363 (100)	4[a]	
Educational level of the Parents/Guardians					
Non-formal	20 (37.7)	33 (63.3)	53 (14.6)		
Primary	21 (53.8)	18 (46.2)	39 (10.7)		
Secondary	33 (45.2)	40 (54.8)	73 (20.1)	2.	0.420
Tertiary	82 (41.4)	116 (58.6)	198 (54.5)	81	
Total	156 (43.0)	207 (57.0)	363 (100)	9[a]	
Marital status of the parents/Guardians					
Single	26 (41.9)	36 (58.1)	62 (17.1)		
Married	115 (41.8)	160 (58.2)	275 (75.8)	2.	0.452
Divorced	8 (61.5)	5 (38.8)	13 (3.6)	63	
Widow	7 (53.8)	6 (46.2)	13 (3.6)	2[a]	
Total	156 (43.0)	363 (100)	363 (100)		
Occupation of the Parent/Guardians					
Civil servant	76 (39.8)	115 (60.2)	191 (52.6)		
Retiree	12 (48.0)	13 (52.0)	25 (6.9)		
Farmer	34 (40.0)	51 (60.0)	85 (23.4)	4.	0.178
Other	34 (54.8)	28 (45.2)	62 (17.1)	91	
Total	156 (43.0)	207 (57.0)	363 (100)	6[a]	
Income of the family(/month)					
₦30,000-60,000	63 (40.1)	94 (59.9)	157 (43.3)	2.	0.653
₦61,000-90,000	48 (44.0)	61 (56.0)	109 (30.0)	45	
₦90,000-120,000	31 (50.8)	30 (49.2)	61 (16.8)	3[a]	
₦121,000-150,000	13 (38.2)	21 (61.8)	34 (9.4)		
Others	1 (50.0)	1 (50.0)	2 (0.6)		
Total	156 (43.0)	207 (57.0)	363 (100)		

Table 2: Association between malaria in children and environmental risk factors (n=363)

Variable/Category	Positive N (%)	Negative N (%)	Total N (%)	χ^2	p-value
District					
Rural	79 (42.2)	108 (57.8)	187 (51.5)	0.084[a]	0.772
Urban	77 (43.8)	99 (56.3)	176 (48.5)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Main wall material for dwelling					
Re-used wood	26 (48.1)	28 (51.9)	54 (14.9)		
Uncovered adobe	34 (42.5)	46 (57.5)	80 (22.0)		
Covered adobe	75 (43.1)	99 (57.0)	174 (47.9)	2.393[a]	0.664
Bamboo with mud	12 (46.2)	14 (53.8)	26 (7.2)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Floor materials for dwelling					
Ceramic	93 (42.1)	128 (57.9)	221 (60.9)		
Metal	54 (4.1)	67 (55.4)	121 (33.3)		
Cement	2 (66.7)	1 (33.3)	3 (0.8)		
Floor	1 (25.0)	3 (75.0)	4 (1.1)	1.421[a]	0.840
Other	6 (42.9)	8 (57.1)	14 (3.9)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Space between roof and wall					
Yes	109 (45.6)	109 (45.6)	239 (65.84)	1.977[a]	0.160
No	47 (38.8)	77 (62.1)	124 (34.2)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Hospital					
*UMTH	29 (29.3)	70 (70.7)	99 (27.3)		
*SSHM	61 (64.9)	33 (35.1)	94 (25.9)		
*USUMH	34 (39.1)	53 (60.9)	87 (24.0)	27.190[a]	0.00
*MSMH	32 (38.6)	51 (61.4)	83 (22.9)		
Total	156 (43.0)	207 (57.0)	363 (100)		
Dwelling sprayed insecticides in the					
last 12 months	57 (47.9)	62 (52.1)	119 (32.8)		
Yes	50 (36.2)	88 (63.8)	138 (38.0)		
No	49 (46.2)	57 (53.8)	106 (9.2)	4.195[a]	0.123
Do not know	156 (43.0)	207 (57.0)	363 (100)		
Total					

*University of Maiduguri Teaching Hospital (UMTH), *State Specialists Hospital Maiduguri (SSHM)
*Umaru Shehu Ultramodern Hospital (USUMH), *Mohammed Shuwa Memorial Hospital (MSMH)

Table 3: Logistic regression analysis of demographic factors influencing malaria Infection in children.

							95% CI for Exp (B)	
Variable/Category	**B**	**S.E**	**Wald**	**d.f**	**p-value**	**Exp(B)**	**Lower limit**	**Upper limit**
Age of the parents/guardians (in years)	1	1	1.47	4	0.83	1.13	-	2.582
18 – 27	0.13	0.42	0.09	1	0.76	1.09	0.50	2.437
28 – 37	0.03	0.41	0.01	1	0.84	1.40	0.49	3.159
38 – 47	0.34	0.42	0.66	1	0.42	1.41	0.62	3.232
48 – 57	0.34	0.42	0.65	1	0.42			
More than 57								
Gender of subjects (children)								
Male	1	-	-	-	-	-	-	-
Female	-	0.216	3.620	1	0.057	0.663	0.434	1.012
	0.411							
Edu. level of the parental/Guardians			2.787	3	0.426			
Non-formal	-	0.318	0.234	1	0.628	0.857	0.460	1.599
Primary	0.154	0.352	2.025	1	0.155	1.650	0.828	3.291
Secondary	0.501	0.276	0.314	1	0.575	1.167	0.680	2.004
Tertiary	0.154							
Marital status								
Single	-	-						
Married	-	0.583	2.538	3	0.468	-	0.143	-
Divorced	0.800	0.797	1.884	1	0.170	0.449	0.15	1.408
Widow	-	0.625	0.157	1	0.692	0.729		3.374
	0.316		1.617	1	0.203	0.451		1.538
	-							
	0.795							
Occupation of the parent/guardians	-	0.266	4.847	3	0.183	-	0.588	
Civil servant	0.009	0.338	0.001	1	0.974	0.991	0.93	1.670
Retiree	0.600	0.457	3.150	1	0.076	1.385		3.532
Farmer	0.325		0.506	1	0.477	1.821		3.394
Other								
Income of the family								
□30,000-60,000	-	1.424	2.439	4	0.656	0.670	0.041	10.913
□61,000-90,000	0.400	1.427	0.079	1	0.779	0.787	0.048	12.908
□91,000-120,000	-	1.437	0.028	1	0.967	1.033	0.06	17.282
□121,000-150,000	0.240	1.458	0.001	1	0.982	0.619		10.775
Other	0.033	1.414	0.108	1	0.742	1.000		
	-		0.00	1	1.000			
	0.480							
	0.00							

B=Beta, S.E=Standard Error, D.F=Degree of Frædom, Exp(B)=Exponential Beta, 95% CI for Exp(B)=Confidence Interval for Exponential Beta

Table 4: Logistic regression analysis of environmental risk factors influencing malaria infection in children.

Variable/Category	B	S.E	Wald	Df	p-value	Exp(B)	95% CI for Exp (B) Lower limit	Upper limit
District								
Rural	1	-	-	-	-	-	-	-
Urban	-0.061	0.212	0.084	1	0.772	0.940	0.621	1.425
Main wall materials for dwelling			2.352	4	0.671			
Dirt	-0.644	0.562	1.314	1	0.252	0.525	0.174	1.580
Re-used wood	-0.080	0.478	0.028	1	0.867	1.083	0.424	2.767
Uncovered adobe	-0.148	0.454	0.107	1	0.744	0.862	0.354	2.099
Covered adobe	-0.123	0.422	0.086	1	0.770	0.884	0.386	2.022
Bamboo with mud								
Floor materials for dwelling			1.341	4	0.854			
Ceramic	-0.032	0.557	0.003	1	0.955	0.969	0.325	2.886
Metal	0.072	0.570	0.16	1	0.900	1.075	0.351	3.285
Cement	0.981	1.339	0.537	1	0.464	2.667	0.193	36.756
Floor	-0.811	1.275	0.405	1	0.525	0.444	0.037	5.406
Others								
Hospital								
UMTH			25.778	3	0.00			
SSHM	-0.415	0.316	1.730	1	0.188	0.660	0.356	1.226
USUMH	1.080	0.312	11.967	1	0.001	2.946	1.597	5.434
MSMH	0.022	0.315	0.005	1	0.944	1.022	0552	1.895
Dwelling sprayed insecticides in last 12 months			4.172	2	0.124			
Yes	0.067	0.268	0.063	1	0.802	1.069	0.633	1.807
No	-0.414	0.263	2.474	1	0.116	0.661	0.395	1.107
Do not know								
Spaces Between roof & wall of subject's room								
Yes	0.327	0.226	1	0.160	1.374	0.882		
No	-0494	7.112	1	0.008	0.610	2.140		

Discussion

In the present study, the demographic and environmental risk factors of malaria-positive individuals were revealed. Majority of the respondents were within the age group 28-37 years and this tallies with the study conducted in Abia State[15], Nigeria where the majority of the respondents were between the age group 31-40 years. Most participants in this study were middle-aged. This was similar to the findings conducted in elsewhere[15]where most of the participants were aged 31-40 years. This finding was also demonstrated in a study where the highest prevalence of malaria was among children within 13-24 months.[16]

The current study documented that the prevalence of parasitaemia is higher in females than males and this may be associated with the higher residency of the females in the rooms and their frequent sleeping within the rooms. This subjects them to frequent biting from the exophilic and endophagic malaria vector that are resting and taking blood meal in the room. This study also found that being a male is a protective factor against malaria infection. This finding is not in tandem with an earlier study[17] which found that male children had a slightly higher risk of malaria infection compared to their female counterparts. This is because male children are adventurous and often play outdoors, hence their exposure to mosquitoes becomes minimized when compared with the females that reside relatively indoor. Females recorded a higher prevalence of malaria than the males in this study and this was also corroborated by another study which found a significant relationship between gender and malaria status.[16]

Parents' or guardians' educational attainment had no association with malaria prevalence in children. This is because educational exposure alone without financial capability may not prevent contacts between individuals with the malarial vector, because the vector may bite the susceptible host in many places apart from their respective houses without the knowledge of the individual. This finding disagrees with the report that the probability of dying from malaria decreases with an increasing level of education.[18]

The respondents who were divorced recorded the highest percentage of malaria. This may be because of the unorganized life style of the divorcee which may subject her to the biting of malarial vector. This disagrees with the finding from another study conducted in other locations within Nigeria which reported a high prevalence of *P. falciparum* infection malaria among married individuals not divorced.[19]

The result obtained in this study also supports the findings of studies conducted in Ghana where children in the upper wealth quartile were more likely to afford improved houses, education and capacity to use malaria prevention strategies compared to the people of the bottom of wealth index.[20]The lower prevalence of malaria among respondents in rural areas compared to those in urban as documented in this study agrees with the previous studies.[21,22,22] As revealed by the findings of this study, majority of the respondents used wood and cement for the construction of their houses. Poor/unimproved materials used in the construction of houses increased the risk of malaria.[22,23,24]

The odds of malaria infection were higher in children of parents aged 48 – 57 years compared to children of parents aged 28 – 37 years. Similarly, when the age in years was run as a continuous variable, the risk of malaria significantly increased. This is because throughout across the age groups, the odds of malaria infection is above one. This finding is in agreement with the report of Habyarimana and Ramroop where a significant risk of malaria infection was found in all age groups of parents/guardians of the study participants.[1]

The odds of malaria infection in relation to the marital status of the parents/guardians of the children were not significant as even though children whose parents were divorced recorded the highest odds ratios, the association was not significant. Furthermore, the crude odds ratio of malaria infection is higher for children whose parents had other occupations apart from public service, farming and retirees among others. This contradicted an earlier study, which reported that children whose parents were employed had a higher risk of malaria infection.[25]

Having an employed caregiver/household head was related to malaria infection.[26] The crude odds of malaria were found to be higher for under five children whose parents earned between 91,000-120,000 compared to those who earned between 30,000 – 60,000. This supports the finding of studies conducted in Ghana and Uganda that children in the upper wealth quartile have a lower risk of malaria infection compared to those at the bottom of the wealth index.[19,26]

This study indicated that the crude odds of children residing in urban areas were high compared to ones residing in rural areas. Individuals residing in urban areas had a higher risk of malaria infection because people in urban settings are prone to many diverse breeding sites of the malaria vector when compared to those living in the rural seeting.[27]

The cost of transportation, consultation and medications at health centres may be unaffordable for some families, hence early care for infected children is hindered. Household factors such as main floor material, main wall material and availability of electricity were closely related to malaria risk factors.[28] However, this disagrees with a study conducted in West Africa that better-constructed houses are associated with a lower risk of malaria infection.[29] Moreover, the prevalence of malaria in the children varied with the hospitals studied. This is in accordance with what was reported in another study which pointed out that the study participants residing in Lekwe and Mbetta showed a higher odd of being infected with malaria.[30]

Children of parents that earned between ₦91, 000-120, 000 per month recorded higher prevalence of malaria parasite infection when compared with those who earned between ₦30,000 – 60, 000 per month. This finding is in agreement with previous studies which documented that the poorest households may have had poor-quality houses that created an environment conducive to the spread of malaria.[31]

The implication of the findings of this research include the susceptibility of the female gender to Plasmodium parasite. Government and community in general shall direct their thinking on the vulnerability of female to malaria infection due to their frequent domestication at home, which can enable endophilic and endophagic mosquitoes to easily bite them when compared to males that are always found outside. By this, the study has provided a baseline data to state governments, Federal Government as well as other relevant health agencies in Nigeria on the influence of gender in malaria infection risk.

Some of the limitations of this study include lack of funding that limited us to conduct a rapid diagnostic test for the detection of malaria, which is more sensitive compared to microscopy. Therefore, it is recommended for a future researcher to employ the use of RDT, considering the fact that Maiduguri in Borno State is a malaria endemic community.

Conclusion

The study found that malaria parasitaemia in under-five years old children in Maiduguri is influenced by sex of the children and the nature of buildings habited by residents. We recommend that government should scale up efforts and give priority to the provision of measures that can prevent infection with *Plasmodium* parasite in children. Furthermore, hospital management shall amplify efforts to provide effective measures that can curtail the possibility of mosquito bites to hospitalized patients. Such efforts include screening their windows with glasses, distribution of treated nets and ensuring regular indoor and outdoor insecticide spraying to decimate the vector of malaria. Regular and consistent microscopic examination of children in each hospital in Maiduguri is strictly recommended.

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