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Coinfection of malaria and tuberculosis among bacteriologically confirmed tuberculosis cases in Lagos, Nigeria

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ABSTRACT

Objective: To estimate the prevalence of malaria and tuberculosis (TB) coinfection among bacteriologically confirmed TB patients attending treatment clinics in Lagos, Nigeria, and to identify associated risks or protective factors.

Methods: A cross-sectional study was conducted in five TB treatment clinics in Lagos. All participants had bacteriologically confirmed TB. Malaria infection was diagnosed by examination of Giemsa-stained thick and thin blood smears under light microscopy. Data on demographics, medical history, and use of vector control tools (*e.g.*, insecticide sprays, insecticide-treated bed nets, chemoprophylaxis) were collected using interviewer-administered pre-tested structured questionnaires.

Results: Out of 446 TB patients, 261 (58.5%) were male, with a mean age of 35.8±13.4 years; 84.1% were HIV-negative. Malaria/TB coinfection was observed in 2.2% (10/446), among newly diagnosed (anti-TB drug naïve), and mostly in patients aged 25–34 years. Only *Plasmodium falciparum* was detected. The use of indoor insecticide spray was significantly associated with reduced malaria/TB coinfection risk with users less likely to be infected than non-users (*P*=0.04; *OR*=0.26; 95%*CI*: 0.07–0.94).

Conclusions: Malaria coinfection was relatively uncommon in TB patients in Lagos, but when present it occurred in newly diagnosed, treatment-naïve individuals. Indoor insecticide spraying was protective against malaria in TB patients. These findings may suggest the potential value of integrating vector control strategies into TB care programs in malaria-endemic settings.

KEYWORDS: Coinfection; Lagos; Malaria; Tuberculosis

1. Introduction

Malaria and tuberculosis (TB) are important causes of morbidity and mortality in Africa, and their control remains a great challenge. In 2023, globally, an estimated 263 million clinical malaria cases and 597 000 malaria deaths occurred[1]. Globally, there were approximately 8.2 million new TB cases and 1.25 million TB-related deaths. Nigeria alone accounted for 31% of malaria deaths

Significance

In sub-Saharan Africa, malaria and tuberculosis (TB) occur frequently, but reported coinfection rates vary widely, and data from Nigeria remain limited. This study provides information on the prevalence of malaria/TB coinfection among bacteriologically confirmed TB patients in Lagos and identifies indoor insecticide spraying as a significant protective factor. The findings highlight the low but notable burden of malaria/TB coinfection and support integrating vector-control measures into TB care programs.

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and 4.5% of the global TB burden[2]. In sub-Saharan Africa region with high disease incidence, human populations are rarely exposed to just a single pathogen; however, concurrent infections with multiple pathogens are an under-recognized public health issue. With the overlap of endemic regions between TB and malaria, coinfection of these diseases in the population is expected.

TB and malaria disproportionately affect the poor[3], who are more exposed to the infection, have the least access to health services, and suffer more from the consequences of the diseases. Both diseases are often related to poverty and a suitable environment for pathogens to thrive and spread. Poor living conditions expose inhabitants to higher infection risks and the transmission of various infectious diseases and possible coinfections. Several interlinked factors contribute to this progression, namely, the spread of the HIV/AIDS pandemic, poverty, overcrowding, malnutrition, the challenges of case detection, and the rising incidence of antimicrobial drug resistance[3].

Malaria and TB coinfection usually present with nonspecific signs and symptoms, and both diseases are associated with extremely high mortality in the absence of timely recognition and prompt therapy[4]. Symptoms of uncomplicated malaria are clinically similar to other severe febrile illnesses. A study showed that the early stage of tuberculosis can masquerade as “constant malaria”; therefore, in endemic areas, parasitological confirmation of malaria is often advocated. The most important consequence of treating only malaria when no parasitaemia exists is failure to address other life-threatening diseases[5].

Malaria presents with a wide clinical spectrum ranging from asymptomatic infection to severe anaemia and neurological complications. Although host immune responses influence disease severity, broader environmental and epidemiological factors such as transmission intensity, co-existing infections, and healthcare access play a major role in determining clinical outcomes[6].

Both malaria and TB interact with the host immune system, but the detailed mechanisms of their interaction remain incompletely understood. Experimental studies suggest that malaria may worsen TB outcomes by disrupting immune balance and affecting macrophage -cell activity[7–11]. However, evidence in humans remains limited, and the immunological interaction between both diseases is not yet fully defined.

In contrast to the extensive literature on malaria/HIV and TB/HIV coinfections, malaria/TB coinfection has received relatively little epidemiological attention. Available studies report highly variable prevalence rates, including 1.5% in Limbe, Cameroon[12], 2.2% in Kampala, Uganda[13], 4.1% in the study in Mwanza, Tanzania[14], and 37% in a retrospective study from Luanda, Angola[15]. These disparities likely reflect differences in malaria transmission intensity, diagnostic approaches, study designs, and case definitions across settings. Given the overlapping geographical distribution of malaria and TB in many African countries, understanding the epidemiology of their coinfection is essential. More robust data are needed to clarify the burden and clinical consequences of concurrent infections. This study therefore aims to determine the prevalence of malaria/TB coinfections among bacteriologically confirmed TB cases in selected TB treatment clinics in the Lagos, the southwestern zone of Nigeria. Improved knowledge of the prevalence and associated clinical factors will support better strategies for early diagnosis, management, and control of both diseases in endemic regions.

2. Methods

2.1. Study area

The study was conducted in Lagos State, Nigeria. Lagos is the center of commerce and accounts for more than 70% of the nation’s industrial and commercial establishments. It is located in the southwestern part of Nigeria on the west coast of Africa, within latitudes 6°23′N and 6°41′N and longitudes 2°42′E and 3°42′E. Lagos State is one of the most populous states in Nigeria, occupying approximately 3 577.28 km^2 with a projected population of 24 821 418 in 2017[16]. Lagos is hypo-endemic for malaria with moderate and stable transmission that peaks during the wet season due to an increase in the population of mosquitoes. Lagos has a small landmass with a very high population, resulting in enormous overcrowding in homes, public places and transportation.

2.2. Study design and sites

The cross-sectional study was performed on participants with bacteriologically confirmed pulmonary TB by either a positive GeneXpert or sputum smear result identified from the TB clinic and laboratory register daily throughout the duration of the study and consented to participate in the study.

The study was conducted at the TB clinics of five locations within Lagos, Nigeria. These sites included the Nigeria Institute of Medical Research (NIMR) in Yaba (6.5142° N, 3.3710° E), Mainland Hospital (MLH) also in Yaba (6.5222° N, 3.3768° E), Randle General Hospital (RGH) in Surulere (6.5086° N, 3.3576° E), St Theresa Clinic (STC) in Amukoko, Ajegunle (N 6° 27' 52.6824", E 3° 27' 8.4132"), and Mushin General Hospital (MGH) in Mushin (6.5312° N, 3.3463° E). These health facilities are situated in urban and semi-urban areas of Lagos State and were selected based on the large population of patients across the state who assess TB care

in the facilities. NIMR and MLH are tertiary and secondary health institutions, respectively, and both serve as referral sites for the diagnosis and treatment monitoring of patients with complicated TB cases and HIV.

2.3. Sample size determination for population study

The sample size was calculated using the online sample size calculator for population survey, for a target population greater than 10 000, the standard normal deviate set at 95%*CI* and level of significance set at 0.05. Minimum sample size (n) of 213 based on the malaria prevalence in Lagos at 14.7%[17], with 10% non-response allowance.

2.4. Sample collection and criteria of inclusion and exclusion

Finger prick blood was used to prepare thick and thin blood smears for malaria diagnosis. An interviewer-administered pretested structured questionnaire was used to obtain the participants' demographic data, medical history, and clinical symptoms. Patients' history of malaria infection, antimalarial drug use, and use of malaria prevention measures were also obtained. Patients' TB treatment categories and HIV status were extracted from the clinic register.

We included participants who were bacteriologically confirmed TB positive by Xpert MTB/RIF and Ziehl-Neelsen (ZN) sputum smear and consented to participate in the study. Participants that had received TB treatment for two weeks prior to the study were excluded as TB treatment significantly reduces bacillary load and could influence the immune responses.

2.5. Malaria parasite detection

The prepared thick and thin blood smears were stained with 3% Giemsa solution for approximately 45 min following the standard guidelines[18]. The stained smears were examined under an oil immersion (×100) objective using a light microscope by two microscopists, and parasite counts were recorded per number of white blood cells (WBCs) observed using proper counting algorithms. In the case of ⩾20% variance in counts between primary and secondary microscopists, the counts closest to that of a third reader were retained. A slide was declared negative only after observing no parasite in 100 microscopic high-power fields. Parasite density was estimated assuming an average absolute WBC of 8000cells/μL of blood by:

$$\text{Parasites/}\mu\text{L of blood} = \frac{\text{Number of Malaria parasites counted} \times \text{absolute WBC count of patients}}{\text{WBC count}}$$

2.6. Diagnosis of TB

Standard techniques were employed in the laboratory diagnosis of TB according to National TB and Leprosy Control Program Guidelines and World Health Organization (WHO) recommendations[19] using Xpert MTB/RIF and Ziehl-Neelsen (ZN) sputum smear for 86% (384/446) and 14% (62/446) of study participants, respectively. This was extracted from the TB laboratory result register of the TB treatment centers.

2.7. Statistical analysis

Data generated from the study was entered and analyzed using the Statistical Package for Social Sciences (SPSS) IBM for Windows version 26.0. Descriptive statistics such as frequencies, proportions, means and confidence intervals were used to summarize the data. Comparisons of categorical variables and significant associations were made with Pearson's *Chi*-square and Fisher's exact test as appropriate. A value of $P<0.05$ was considered statistically significant. Multivariate analysis was not conducted because the number of TB/malaria coinfection cases was too small to support reliable modeling.

2.8. Ethical statement

Ethical approval to conduct the study was obtained from the Institutional Review Board of the Nigerian Institute of Medical Research, Yaba, Lagos (IRB/10/122). Permission to carry out the study was granted by the Lagos State Health Management Board and management of the TB clinics (SHMB/728/Vol.VI/). Written informed consent/assent was obtained from each participant/caregiver, and the participants' confidentiality was maintained throughout the study. The positive malaria cases detected during the study were treated with artemisinin-based combination therapy by the consulting physician at the clinics.

3. Results

3.1. Demographic information of the participants

A total of 929 participants screened in this study while 446 bacteriologically confirmed pulmonary TB cases were recruited from five TB treatment clinics in Lagos, Nigeria (Figure 1). Totally 58.5% of the participants were males, (95%*Cl*: 53.79-63.14), aged between 9 and 85 years with a mean age of 35.8±13.4 years. Totally 55.2% of the participants had received some level of education up

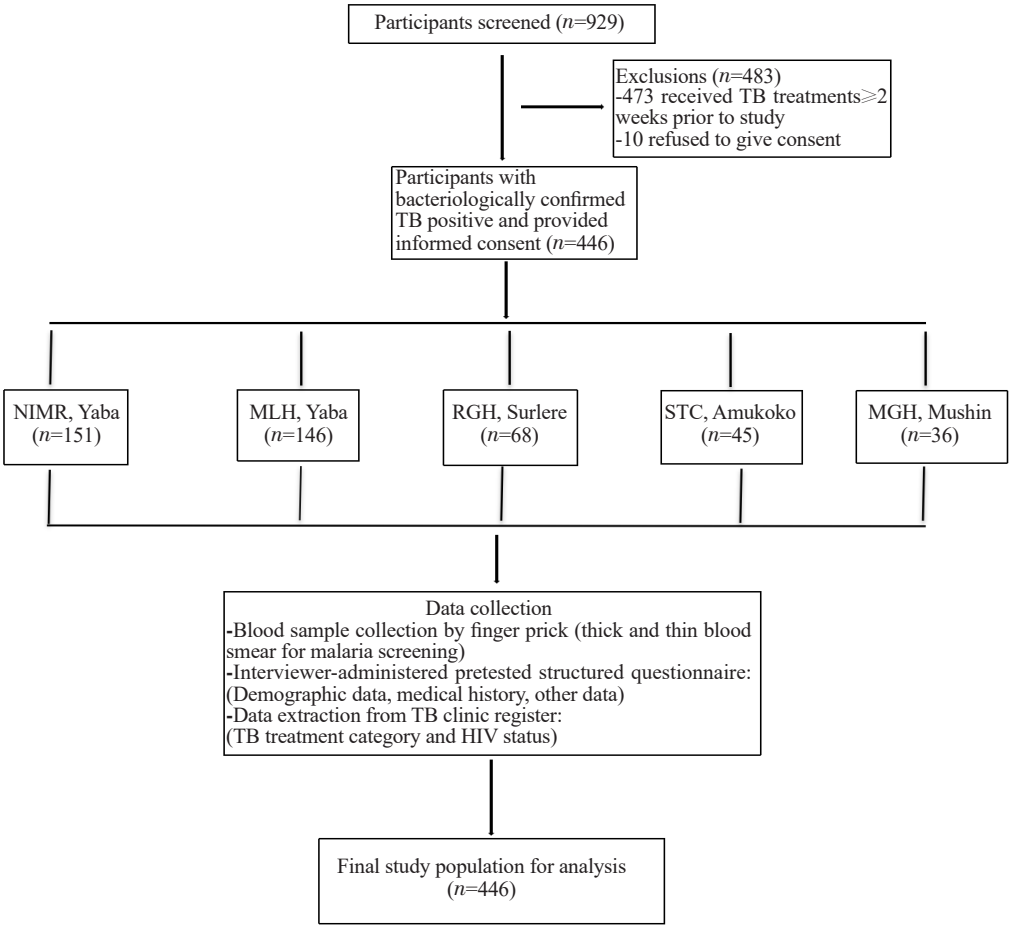

Figure 1. Flowchart of the study.

Table 1. Demographic characteristics of participants and the association between malaria/TB co-infection and demographic variables in five selected TB clinics in Lagos.

Variables	Sample size *n*=446	Malaria positive	95%*CI*	χ^2	*P*	Df
Sex						
Male	261 (58.5)	4(1.5)	53.79-63.14	1.445[b]	0.33	1
Female	185 (41.5)	6(3.2)	36.86-46.21			
Age, years						
≥24	85 (19.1)	2(2.4)	15.52-23.02	1.386[a]	0.50	2
25 – 34	152 (34.1)	5(3.3)	29.69-38.69			
≤35	209 (46.9)	3(1.4)	42.15-51.61			
Mean age: 35.84 ±13.40						
Marital status						
Married	242 (54.3)	3(1.6)	49.51-58.95	2.498[a]	0.29	2
Single	192 (43.0)	6(2.5)	38.40-47.79			
Widowed	12 (2.7)	1(8.3)	1.4-4.65			
Educational status						
Primary	98 (22.0)	4(4.1)	18.21-26.11	1.976[a]	0.38	2
Secondary	246 (55.2)	4(1.6)	50.41-59.84			
Tertiary	102 (22.9)	2(2.0)	19.05-27.05			
Occupation						
Trader	164 (36.8)	5(3.0)	32.29-41.43	1.105[a]	0.78	3
Artisans	149 (33.4)	2(1.3)	29.04-38.00			
Employed	54 (12.1)	1(1.9)	9.23-15.50			
Student	79 (17.7)	2(2.5)	14.28-21.58			

Note: a=Pearson's *Chi*-Square; b=Fisher's Exact Test; Data were expressed as *n*(%).

to the secondary level (95%*Cl*: 50.41-59.84); and 54.3%(95%*Cl*: 49.51-58.95) were married. Among the participants, trading was the highest occupation, as shown in Table 1.

3.2. Relationship between malaria/TB coinfection and demographic characteristics of the participants

There was no significant difference in malaria prevalence among TB subjects by sex (*P*=0.33) or age group (*P*=0.50) (Table 1), although malaria/TB coinfection was reported most among the age group 25-34 years. Majority of the malaria/TB coinfected cases in the study were married with secondary level of education and trading as occupation, yet there was no association between marital status, educational status and occupation (*P*=0.29; *P*=0.38; *P*=0.78 respectively) and malaria/TB coinfection (Table 1).

3.3. Classification of study participants by TB treatment and HIV status

A history of malaria treatment in the last one month before the study was reported by 34.3% of study participants, and 25.8% used artemisinin-based combination therapy for malaria treatment at home. About 76.2% of the participants were new TB cases and 84.1% were HIV negative (Table 2). Around 15.9% were HIV positive TB cases, 77.0% were taking cotrimoxazole while 49.2% were taking anti-retroviral therapy. All the malaria/TB coinfected subjects were TB treatment naïve (new) cases.

3.4. Prevalence of malaria and TB coinfection

The overall prevalence of malaria and TB coinfection in the study was 2.2%. All participants with malaria had *Plasmodium (P.) falciparum* mono-infection. The highest prevalence of malaria and TB coinfections 5.9% (4/10) were recorded at Randle General Hospital TB Clinic, while least coinfections (0.7%) were recorded in Mainland Hospital, Yaba (Table 3). There was no significant difference (χ^2=5.818; *P*=0.213) in the prevalence of malaria and TB coinfections among the TB cases at the various clinics, however, the limited number of cases reduces the power of this comparison.

Table 2. Classification of study participants by TB treatment and HIV status.

Variables	Number of patients (*n*=446)	95% *CI*
TB treatment classification of the participants		
New	340 (76.2)	72.00-80.11
Relapse	65 (14.6)	11.43-18.20
Treatment failure	41 (9.2)	6.68-12.26
HIV Status		
Negative	375 (84.1)	80.35-87.35
Positive	71 (15.9)	12.65-19.65

n=Total number of the study participants; Data were expressed as *n*(%).

Table 3. Distribution of malaria and TB co-infection by selected TB Clinics in Lagos State.

Study Site	Number examined	Number of malaria and TB coinfection	χ^2	*P*	Df
Randle General Hospital	68	4 (5.9)	5.818	0.21	4
Nigerian Institute of Medical Research TB clinic	151	3 (2.0)			
St Theresa Clinic Amukoko	45	1 (2.2)			
Mushin General Hospital	36	1 (2.8)			
Mainland Hospital, Yaba	146	1 (0.7)			
Total	446	10 (2.2)			

χ^2=Fisher's Exact Test; Data were expressed as *n*(%).

Table 4. Risk factors of malaria/TB coinfection at the selected clinics in Lagos, Nigeria.

Malaria control intervention	Number of participants	Malaria positive	χ^2	*P*
Use of long-lasting insecticide treated bed net at home				
Yes	8 (1.8)	0(0)	0.187[b]	1.00
No	438 (98.2)	10(2.3)		
Use of insecticide spray at home				
Yes	317 (71.1)	4 (1.3)	4.805[b]	0.04
No	129 (28.9)	6 (4.7)		
Took malaria medicine at home in the last 1 month				
Yes	153 (34.3)	6 (3.9)	2.997[a]	0.08
No	293 (65.7)	4 (1.4)		

Note: a=Pearson's *Chi*-Square; b=Fisher's Exact Test; Data were expressed as *n*(%).

The majority 98.2% (438/446) of participants reported no ownership of long-lasting insecticide-treated bed net and not sleeping under a mosquito net the previous night. A history of malaria treatment in the last month before the study was not associated with malaria/TB coinfection (*P*=0.08), but indoor spraying of accommodation units or houses in the last one month with insecticide was reported by 71.1% (317/446) of the participants (Table 4). Among the participants, insecticide spray at home was associated with a lower burden of malaria and TB coinfection. Specifically, 4 out of 317 participants (1.3%) who used insecticide spray at home tested positive for coinfection, while 313 (98.7%) tested negative. In contrast, among those who did not use insecticide spray at home, 6 out of 129 participants tested positive for coinfection, and 123 tested negative. The *OR* for coinfection among those using insecticide spray at home was 0.26, with a 95%*CI* of 0.07-0.94, and a *P*-value of 0.04, indicating a statistically significant association. However, the small number of cases limits the power of this comparison.

4. Discussion

Plasmodium and *Mycobacterium* tuberculosis infections are endemic tropical diseases occurring most commonly in impoverished areas of the world; therefore, coinfection is expected to occur in individuals in these zones of intense transmission. The study demonstrated a low prevalence of malaria among TB patients, which is similar to reports from Kampala, Uganda, that reported 2.2% prevalence of malaria among bacteriologically confirmed adult TB patients[13]. A hospital-based study in Limbe, South West region, Cameron, found a prevalence of 1.5%[13], while a 4.1% prevalence was reported in Mwanza, Tanzania[14]. A higher malaria prevalence of 37.5% was reported in a retrospective study on children and clinically diagnosed TB patients in Luanda, Angola[15].

Some studies have suggested that prior *Mycobacterium tuberculosis* infection may influence susceptibility to malaria by increasing inflammatory tissue responses or through general immune activation[10,11]. This reduction in malaria prevalence has been associated with an enhanced Th1 type immune response induced by *Mycobacterium tuberculosis* infection, which is also protective against malaria infection[7,11], however these immunological interactions remain incompletely understood and their relevance to humans is uncertain.

In this study, over one-third of participants (34.3%) reported recent malaria treatment, which might partly explain the low observed prevalence of coinfection. The study participants were mostly adults from urban and semi-urban settings with low malaria prevalence[20,21]. Lagos and other rapidly growing urban areas experience lower but more heterogeneous malaria transmission due to improved housing, widespread insecticide-treated net use, environmental modifications, and reduced mosquito breeding sites. While TB prevalence is largely driven by overcrowding, poor ventilation, and socioeconomic factors common in densely populated urban settlements, these same factors may contribute to the observed low coinfection prevalence.

All participants with malaria in our study were infected with *P. falciparum*. A study[22] reported that 80%–95% of malaria infections in tropical Africa were caused by *P. falciparum* while national figures from the Federal Ministry of Health in Nigeria showed that *P. falciparum* accounted for approximately 98% of malaria cases in Nigeria[23].

Insecticide-treated bed nets reduce malaria infection by providing both mechanical and chemical barriers to mosquito bites and are efficacious in children and adults. The use of long lasting insecticide-treated bed nets and antimalarial agents did not correlate with malaria and TB coinfection in this study. In contrast, a study[24], showed that malaria vector control interventions, personal protection, and cotrimoxazole prophylaxis were safe and low-cost measures to reduce in-hospital mortality in hospitalized TB patients with poor clinical status and/or disseminated disease. Furthermore, a mathematical model[25] that incorporated some of the basic epidemiological features of the dynamics of malaria and TB and the effectiveness of current intervention strategies for these two diseases, showed that the malaria preventive strategy of using long-lasting insecticide-treated nets prevented more new cases of malaria/TB mixed infection than the TB-only preventive strategy. The study also showed that TB subjects that used insecticide spray at home were less likes to have malaria than those did not.

The small number of participants with malaria/TB coinfection limited the statistical power to detect meaningful differences, and this represents a key limitation of the study.

5. Conclusions

Malaria coinfection among TB cases was uncommon in this study. The use of insecticide sprays was associated with lower odds of malaria infection, however, the small sample size limits the strength of this finding. Further evaluation of associated factors is recommended.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' contributions

All authors were responsible for the conception and design of the study as well as the writing of the manuscript. Oyibo W provided administrative support for the project. Igbasi U was in charge of the collection and assembly of data, in addition to the analysis and interpretation of the data.

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