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Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Coinfection with Malaria in Selected States in Nigeria

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Abstract

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and *Plasmodium species* are the causative agents of coronavirus disease 2019 (COVID-19) and malaria respectively with similar clinical presentations. The objective of this study is to determine the burden of co-infection of SARS-CoV-2 and malaria in the general population. Five (5 mLs) of blood

samples were collected for SARS-CoV-2 and malaria parasite test. The malaria test was performed using a commercially available one-step malaria antigen *Plasmodium falciparum* histidine-rich protein 2 (Pf HRP-II) rapid test kit. The results of the study showed that the participants that were coinfected with SARS-CoV-2 IgG and malaria were 13 (2.5%) in Lagos, 1114 (39.1%) in Delta and 49 (2.3%) in Sokoto States. The prevalence of coinfection of SARS-CoV-2 and malaria in urban areas in Lagos, Delta and Sokoto States were 7 (2.2%), 1373 (48.1%), and 5 (0.2%) respectively. In rural areas, the prevalence of coinfection of SARS-CoV-2 and malaria in Lagos, Delta and Sokoto States were 6 (0.3%), 365 (12.8%), and 44 (2.1%) respectively in this study. This suggests that participants in the urban areas were more prone to co-infections than the rural areas in Lagos and Delta states, while it was otherwise in Sokoto State. In conclusion, the co-infection of SARS-CoV-2 and malaria was very high in Delta State compared to the other States. It is important for clinics to screen for both diseases when patients present with symptoms of malaria. This is because the infections have similar symptoms and the public is quick to assume malaria infection without diagnosing for COVID-19 and vice versa.

Keywords

SARS-CoV-2, Malaria, Coinfection

1. Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and *Plasmodium* spp. are pathogenic microorganisms that cause coronavirus disease 2019 (COVID-19) and malaria respectively [1] [2]. Infectious diseases are among the leading causes of death worldwide [3]. Even though SARS-CoV-2 and malaria parasites differ a lot in classification, being that the former is a virus and the latter a parasite, they present similar symptoms such as fever, dry cough, and malaise in infected individuals [4] [5] [6]. SARS-CoV-2 also responds to existing antimalarial drugs such as chloroquine in combination with other therapeutics [4] [7] [8]. Due to the similarities in the epidemiology of these infectious diseases, misdiagnosis and/or cross-immunity can exist in people infected with SARS-CoV-2 or malaria parasites, especially in countries with limited resources and those endemic to malaria parasites [5] [7]. Therefore, the official data on the prevalence of SARS-CoV-2 alone may not be a true reflection of the current burden of COVID-19 disease [5] [6]. In addition, antibodies against SARS-CoV-2 provide more detailed information on possible infection with SARS-CoV-2 within a population [9]. The reason is that anti-SARS-CoV-2 IgG is normally produced in individuals who have a symptomatic or asymptomatic SARS-CoV-2 viral infection. Information on the prevalence of SARS-CoV-2, anti-SARS-CoV-2 IgG and malaria parasites in Lagos, Delta and Sokoto States will provide a broader estimate of the burden of SARS-CoV-2 IgG and malaria para-

sites in these states and also guide public health policies in the fight against these infectious diseases. The prevalence of SARS-CoV-2 IgG, malaria parasite and their coinfections will be discussed here.

As of January 11th 2024 the global prevalence of SARS-CoV-2 was 701,508,817 confirmed cases with about 6,966,767 deaths reported to the World Health Organization [10]. In Africa, the prevalence was 9,568,942 confirmed cases and over 175,477 deaths. Nigeria has a prevalence record of 267,173 confirmed cases and 3155 deaths reported to the World Health Organization as of 11th January, 2024 [10].

The prevalence of SARS-CoV-2 in Lagos State as of 4th April 2022 was 99,226 confirmed cases and 769 deaths, Delta State had 5717 confirmed cases and 111 deaths, and Sokoto had 817 confirmed cases and 28 deaths [11]. According to the Nigerian Centre for Disease Control (NCDC) and Nigerian Institute of Medical Research (NIMR) SARS-CoV-2 antibody survey, the prevalence of SARS-CoV-2 antibodies in households in Lagos State was 23.3% (95% Cl 20.3 - 26.0), 36.8% (95% Cl 32.8 - 41.0) in Delta State, and 65.3% (95% Cl 38.3 - 71.7) in Sokoto State [12]. The study also stated that the seroprevalence of anti-SARS-CoV-2 is higher than the prevalence rate of COVID-19 disease that was detected by SARS-CoV-2 surveillance within Lagos, Delta and Sokoto States populations [12].

Malaria is a life-threatening public health parasitic disease. There were an estimated 247 million malaria cases and 619,000 deaths due to malaria in 2021 (WHO, 2021). About two-thirds (47,000) of the additional malaria deaths were due to disruptions in the provision of malaria prevention, diagnosis and treatment during the pandemic (WHO, 2021). The prevalence of malaria parasites in children under the age of 5 years in States was 3%, 10% and 36% in Lagos, Delta and Sokoto States respectively [13]. The prevalence of malaria has drastically decreased especially in urban areas. This could be due to different malaria control intervention programmes by the Government in urban areas [14].

Early in the COVID-19 pandemic, WHO projected a possible doubling of deaths in 2020 in sub-Saharan Africa. The strenuous efforts of malaria-endemic countries and their partners to maintain malaria services during the pandemic averted this worst-case scenario [15]. Many countries experienced disruptions to malaria prevention, diagnosis and treatment. In sub-Saharan Africa, there was an estimated 12% increase in malaria deaths in 2020 over 2019. This highlights the consequences of even moderate service disruptions to malaria services in a population at risk [15].

There was therefore a need to conduct a population-based study incorporating regions with a high and low burden of the disease as well as rural and urban settings. Hence, our study aimed at determining the co-infection of SARS-CoV-2 with malaria in the general population.

The role of asymptomatic and pre-symptomatic individuals in transmission of SARS-CoV-2 and malaria co-infection was determined. This is useful in estimating the disease burden and revealing symptom-free infected individuals with

SARS-CoV-2 and malaria. This survey also served as an epidemiological platform that screened participants for COVID-19-related co-morbidities including malaria. The study determined the prevalence of asymptomatic SARS-CoV-2 co-infection with malaria, characterized disease patterns and transmission dynamics in a large population and determined association with comorbidities in a high-prevalence setting. The objective of this study is to estimate the burden of co-infection of SARS-CoV-2 and malaria in Lagos, Delta and Sokoto States, Nigeria.

2. Methods

2.1. Study Design and Settings

This was a household cross-sectional study of COVID-19 coinfection with malaria. The study was conducted in Lagos, Sokoto and Delta States in Nigeria. Lagos is located in the southwest of Nigeria. It is the most populous state in the country. Sokoto is located in the extreme northwest of the country, bounded by the Republic of Niger, Nasarawa and Kebbi States. Delta State is located in the south-south geopolitical zone of the country. The study period was October 2020 for Lagos State, March 2021 for Sokoto State and July 2021 for Delta State.

2.2. Study Population and Site

The study population consisted of all members of the household, irrespective of age. Clinical data and biological specimens were collected from study participants who consented.

Inclusion criteria: All persons living in the household including children were invited to participate in the study.

Exclusion criteria: Household members who were in residential institutions, such as boarding schools, hostels, dormitories, or prisons were excluded. Household members who refused to give informed consent, or contraindication to venipuncture were also excluded.

2.3. Sample Size Determination and Sampling Procedure

The overall sample size was determined by the number of blood draws needed to obtain relatively robust estimates of SARS-CoV-2 seroprevalence for each stratum (states). Urban EAs (enumeration areas) were oversampled in the two predominantly rural states to yield more precise estimates for the urban and rural strata within each state, state-level prevalence was the primary determinant of sample size. Thirty-four EAs were sampled per state, with 20 households sampled per EA in Sokoto and Delta State, while 30 EAs were sampled in Lagos State with 20 households because of higher prevalence in Lagos State during the pandemic. The sample size table (Table 1) took into account assumptions on relative standard error (RSE), which is the standard error of the survey point estimate divided by the point estimate), an assumed 68% response rate, and estimated design effect, all at 95% confidence intervals (CI). The estimated RSEs

Table 1. Sample size.

State	*EAs	*Num of HH per EA	Total HHs	Ave. HH Size	Total Sample size
Lagos	30	20	600	4	2400
Sokoto	34	20	680	5.3	3604
Delta	34	20	680	4.5	3060

*EAs: Enumeration Areas, *Num HH: Numbers of Households.

and 95% CIs take into account adjustments for non-response, number of individuals per household, individual non-response, and refusal of blood testing or specimen loss.

2.4. Data Collection

Study-related information, including demographic characteristics, clinical information, and exposure information, was collected by a trained research assistant using an electronic data collection tool (REDCap) and hard copies of the data collection tool as backup.

2.5. Specimen Collection and Transport

Five milliliters of venous blood was collected from each participant into a plain vacutainer bottle. At the study locations, blood samples were examined for malaria using the commercially available one-step malaria antigen *Plasmodium falciparum* (HRP-II) rapid diagnostic test (RDT) kit, performed according to the manufacturer's instructions. Briefly, 5 microliters of whole blood samples were transferred into the specimen well, the assay diluent (4 drops) was added. The test kit was left for 15 minutes after which the results were read and collated. Individuals who tested positive were administered antimalarials by the study physician according to standard prescriptions. The remaining blood samples were transported in ice packs to the state satellite laboratories, centrifuged and the sera collected into clean cryovials. The serum samples were stored at −20˚C and shipped to the Center for Human Virology and Genomics, at the Nigerian Institute of Medical Research for further analysis.

2.6. Laboratory Evaluations

Laboratory and infection prevention and control precautions for COVID-19 were observed according to the WHO guidelines.

2.7. Serological Testing

Serum samples were screened for the presence of SARS-COV2 antibodies using Luminex xMAP SARS-CoV-2 Multi-Antigen IgG Assay (multiplexed microsphere-based assay), which targets the nucleocapsid protein, spike protein, and the receptor-binding domain of SARS-CoV-2. The test was carried out according to the manufacturer's instructions.

2.8. Statistical Analyses

Descriptive statistics, such as frequencies and percentages, were used to present the households in Lagos, Sokoto and Delta states and the prevalence of SARS-CoV-2 antibody coinfection with malaria across different demographic and clinical variables. The measures include counts of households selected, not found/destroyed, vacant, occupied, and those that refused to participate as well as the number and percentage of individuals with SARS-CoV-2 only, malaria only, coinfection, and those not infected. Weighted analysis was used to ensure it is representative of the population (Tables 1-4). The data were analyzed using standard STATA 16.0 statistical software. Post-stratification weights were derived for each state using the age-sex distribution from the state-level projection for 2020, based on the 2006 census data. The presented percentages were weighted unless otherwise noted. Wealth quintiles were created using principal component analysis (PCA) methods from the Demographic and Health Surveys. PCA was run for Lagos, Sokoto, and Delta States separately. All household assets (e.g. electricity, radio, television, vehicle), floor material, wall material, primary cooking fuel source, toilet facilities (with the exception of other toilets due to low frequency), and number of household members per sleeping space were included in the wealth index.

2.9. Ethical Approval and Informed Consent

Ethical approval was obtained from the National Health Research Ethics Committee (NHREC/01/01/2007-02/05/2022), NIMR-IRB and the respective states' ethical committees. Social approvals were also obtained from different states. Written Informed consent was obtained from all individuals who participated and only consenting participants had blood samples collected for biological testing by trained phlebotomists. Assent was obtained from all children aged 7 to 17 years before their participation in the study, while consent for children under the legal age of consent was also obtained from a parent or legal guardian.

3. Results

The overall prevalence of SARS-CoV-2 IgG, malaria positivity and in co-infected with SARS-CoV-2 IgG and malaria in this study were 29.8%, 25% and 11.2% respectively.

The participants that had only SARS-CoV-2 IgG were 546 (40.8%) in Lagos, 1216 (58.1%) in Sokoto and 902 (31.1%) in Delta States. Those that were positive for malaria parasites were 54 (7.8%), 574 (27.4%) and 515 (18.1%) participants in Lagos, Sokoto and Delta States respectively. The participants who were co-infected with SARS-CoV-2 IgG and malaria were 13 (2.5%) in Lagos (Table 2), 49 (2.3%) in Sokoto State (Table 3), and 1738 (60.9%) in Delta State (Table 4).

In the urban area of Lagos State, the participants who were co-infected with SARS-CoV-2 (IgG and malaria were 7 (2.2%) while in the rural area, they were 6 (0.3%). Only 10 males and 3 females were co-infected with SARS-CoV-2 and

Table 2. SARS-CoV-2 antibody coinfection with malaria by selected demographic and clinical variables in Lagos.

Characteristics	SARS-CoV-2β only (N=546)		Malaria Positive only N=(54)		Co-infection (N = 13)		Not infected with either (N = 1774)	
	n	%α	N	%	n	%	n	%
Residence								
Urban	492	23.6	32	1.7	7	2.2	239	**74.7**
Rural	54	17.2	22	6.1	6	0.3	1535	**74.3**
Gender								
Males	240	23.0	25	2.5	10	0.9	733	**73.7**
Females	306	22.5	29	2.3	3	0.3	1041	**75.0**
Age groups**								
Children	99	19.2	14	3.2	4	0.8	376	**76.7**
Adolescents and young adults	110	27.8	15	3.6	4	1.0	270	**67.6**
Adults	301	23.3	22	1.6	4	0.3	994	**74.7**
Senior adults	36	21.5	3	1.4	1	0.8	134	**76.4**
Wealth quintile								
Lowest	96	20.3	14	3.0	2	0.4	354	**76.3**
Second	99	20.2	14	2.9	2	0.4	360	**76.6**
Middle	126	26.7	10	1.9	5	1.2	327	**70.3**
Fourth	100	22.2	9	1.9	2	0.6	360	**74.9**
Highest	125	24.3	7	1.8	2	0.4	373	**73.6**
Comorbidities/Pre-existent conditions								
Currently Pregnant	8	19.9	2	2.1	0	0.0	42	**78.0**
Diabetes	0	0.0	0	0.0	0	0.0	6	**100.0**
Hypertension	7	24.4	0	0.0	0	0.0	24	**75.7**
Heart disease	1	19.7	0	0.0	0	0.0	4	**80.3**
Asthma	4	70.7	0	0.0	0	0.0	2	**29.3**
Tuberculosis								
Chronic kidney disease								
Emphysema/Chronic bronchitis/COPD	1	30.6	0	0.0	0	0.0	1	**69.4**
HIV	0	0.0	0	0.0	0	0.0	0	**0.0**
Sickle cell disease	2	22.7	0	0.0	0	0.0	9	**77.3**
Cancer								
Others								
No reported comorbidity	490	23.1	45	2.2	13	0.7	1552	**74.0**
1 co-morbidity	19	21.5	2	0.7	0	0.0	83	**77.8**
2 or more comorbidities	2	41.3	0	0.0	0	0.0	4	**58.7**
Symptomatology*								
Symptomatic	78	17.1	24	5.5	2	0.4	346	**77.0**
Asymptomatic	457	24.2	29	1.5	11	0.7	1382	73.7

*at least one symptom reported since March 2020. **Children defined as less than 10, Adolescents and young adults defined as 10 - 17 years old, adults defined as 18 - 64 years old, and senior adults defined as 65 and over. α All percentages are weighted.

Table 3. SARS-CoV-2 antibody coinfection with malaria by selected demographic and clinical variables in Sokoto.

Characteristics	SARS-CoV-2β only (N = 1216)		Malaria Positive only (N = 574)		Co-Infection (N = 49)		Not infected with either (N = 2048)	
	n	%α	N	%	n	%	n	%
Residence								
Urban	234	11.2	36	1.7	5	0.2	416	19.8
Rural	982	46.9	538	25.7	44	2.1	1632	77.8
Gender								
Males	759	36.3	367	17.5	32	1.5	1278	60.9
Females	457	21.9	207	9.9	17	0.8	770	
Age groups**								
Children	342	16.4	171	8.2	9	0.4	563	26.9
Adolescents and young adults	228	10.9	114	5.4	12	0.6	417	19.9
Adults	601	28.7	263	12.6	24	1.1	997	47.5
Senior adults	45	2.2	26	2.2	4	0.2	71	3.4
Wealth quintile								
Lowest	255	12.2	123	5.9	16	0.8	416	19.9
Second	242	11.6	101	4.8	13	0.6	403	19.2
Middle	246	11.8	101	4.8	3	0.1	414	19.8
Fourth	254	12.2	111	5.3	12	0.6	430	20.5
Highest	219	10.5	138	6.5	5	0.2	384	18.3
Comorbidities/Pre-existent conditions								
Currently Pregnant	11	0.6	8	0.3	4	0.2	17	0.9
Diabetes	16	0.8	9	0.4	0	0.0	27	1.3
Hypertension	21	1.0	12	0.6	0	0.0	44	0.2
Heart disease	1	0.001	0	0.0	0	0.0	2	0.1
Asthma	3	0.01	1	0.01	0	0.0	5	0.2
Tuberculosis	1	0.001	0	0.0	0	0.0	1	0.1
Chronic kidney disease	0	0.0	0	0.0	0	0.0	0	0.0
Emphysema/Chronic bronchitis/COPD	0	0.0	0	0.0	0	0.0	0	0.0
HIV	0	0.0	0	0.0	0	0.0	0	0.0
Sickle cell disease	30	1.4	15	0.7	0	0.0	69	3.2
Cancer	95	4.5	47	2.2	0	0.0	132	6.4
Others	16	0.8	7	0.3	27	12.9	0	0.0
No reported comorbidity								
1 co-morbidity								
2 or more comorbidities								
Symptomatology*								
Symptomatic	1032	49.3	488	23.3	0	0.0	87	4.2
Asymptomatic	46	2.2	19	0.9	47	2.2	1699	81.0

α All percentages are weighted.

Table 4. SARS-CoV-2 antibody coinfection with malaria by selected demographic and clinical variables in Delta.

Characteristics	SARS-CoV-2β only (N = 902)		Malaria Positive only (N = 515)		Co-infection (N = 1738)		Not infected with either (N = 1114)	
	n	%a	N	%	n	%	n	%
Residence								
Urban	710	24.9	291	10.2	1373	48.1	763	**26.8**
Rural	192	6.7	224	7.9	365	12.8	351	**12.3**
Gender								
Males	377	13.2	262	9.2	752	26.4	467	**16.4**
Females	525	18.4	253	8.9	986	34.6	647	**22.7**
Age groups**								
Children	161	5.7	144	5.1	445	15.6	194	**6.8**
Adolescents and young adults	160	17.3	124	4.4	349	12.2	145	**5.1**
Adults	519	18.2	220	7.7	846	29.7	649	**22.8**
Senior adults	62	2.2	27	1.0	98	3.4	126	**4.4**
Wealth quintile								
Lowest	163	5.7	135	4.7	361	12.7	220	**7.7**
Second	189	6.6	119	4.2	317	11.1	252	**8.8**
Middle	198	6.9	107	3.8	338	11.9	227	**8.0**
Fourth	178	6.2	80	2.8	355	12.5	217	**7.6**
Highest	174	6.1	74	2.6	367	12.9	198	**6.9**
Comorbidities/Pre-existent conditions								
Currently Pregnant	8	0.3	6	0.2	23	0.8	8	**0.3**
Diabetes	13	0.5	3	0.1	6	0.2	27	**1.0**
Hypertension	18	0.6	7	0.3	11	0.4	43	**1.5**
Heart disease	1	0.0	1	0.0	0	0	3	**0.1**
Asthma	0	0	1	0.0	3	0.1	2	**0.1**
Tuberculosis	0	0	0	0	1	0.0	0	**0.0**
Chronic kidney disease	0	0	0	0	0	0	0	**0**
Emphysema/Chronic bronchitis/COPD	0	0	0	0	0	0	0	**0**
HIV	0	0	0	0	0	0	0	**0**
Sickle cell disease	33	1.2	18	0.6	29	1.0	55	**1.9**
Cancer	825	28.9	475	16.7	1647	57.8	971	**34.1**
Others	11	0.4	8	0.3	21	0.7	23	**0.8**
No reported comorbidity								
1 co-morbidity								
2 or more comorbidities								
Symptomatology*								
Symptomatic	29	3.22	11	0.4	39	1.4	48	**1.7**
Asymptomatic	**705**	**78.2**	414	14.5	1505	52.8	761	**26.7**

malaria in Lagos State. The participants who were co-infected with SARS-CoV-2 and malaria in urban area were 5 (0.2%) while in the rural areas they were 44 (2.1%). The male participants were 32 (1.5%) and female participants were 17 (0.8) in Sokoto State. In Delta State, the participants who were co-infected with SARS-CoV-2 and malaria in the urban area were 1373 (48.1%), while in the rural area they were 365 (12.8%). Male and female participants who were co-infected with SARS-CoV-2 and malaria were 752 (26.4%) and 986 (34.6%) respectively.

The children, adolescents and young adults who were co-infected with SARS-CoV-2 and malaria in Lagos State were 4 (0.8%), 4 (1.0%), and 5 (1.1%) respectively. In Sokoto State, the children, adolescents and young adults co-infected with SARS-CoV-2 and malaria were 9 (0.4%), 12 (0.6%) and 28 (1.3%) respectively. The children, adolescents, and young adults who were co-infected with SARS-CoV-2 and malaria in Delta State were 445 (15.6%), 349 (12.2%), and 944 (33.1%) respectively.

In Lagos, 2 (0.4%) of symptomatic participants had SARS-CoV-2 antibodies and in malaria, 17% had only SARS-CoV-2 antibodies. While 5.5% had malaria only. In Sokoto state, no symptomatic participant had co-infection of SARS-CoV-2 antibodies and malaria, but asymptomatic participants with co-infections were 47 (2.2%). Symptomatic individuals that had only SARS-CoV-2 antibodies or malaria were 1032 (49.3%) and 488 (23.4%) respectively. In Delta state, 39 (1.4%) of symptomatic participants had co-infections with SARS-CoV-2 antibodies and malaria; 29 (7.5%) of the symptomatic individuals had only SARS-CoV-2 antibodies, while those with only malaria were 11 (0.4%).

There were no comorbidities/pre-existent conditions among the participants in Lagos and Sokoto States with coinfection but the wealth quintile is the highest in the middle class 5 (1.2%) in Lagos State and it is high in the lowest class 16 (0.8%) in Sokoto State. The comorbidities/pre-existent conditions that were observed among the participants in Delta State were diabetes, hypertension and asthma 20 (0.7%), and cancer 1647 (57.8%) while the wealth quintile was observed in the highest class 367 (12.1%).

4. Discussion

Co-infection of SARS-CoV-2 and malaria was first reported in China [16]. Other authors have also reported it in Nigeria [17] [18], Burkina Faso [19], Sudan [20] and India [21]. The symptoms of SARS-CoV-2 and malaria are overlapping [22], leading many people to assume they have a malaria infection when they actually have SARS-CoV-2 [5]. The only way to differentiate between the illnesses is by conducting malaria and SARS-CoV-2 tests. This study showed that co-infection of SARS-CoV-2 and malaria in the participants was common.

This co-infection could be attributed to many factors, including warm weather, lack of proper diagnosis, previous infection with malaria, and the use of antimalarial medicine. Additionally, population genetics appears to play a signifi-

cant role in shaping the COVID-19 dynamics [23]. This is evident from recent genomic screening analyses of the angiotensin-converting enzyme 2 (ACE2) and malaria-associated-variants, which identified 6 candidate genes that might play a role in malaria and COVID-19 incidence and severity [24].

This study showed the co-infection of SARS-CoV-2 and malaria in three states in Nigeria, where SARS-CoV-2 was tested. The lowest co-infection of SARS-CoV-2 and malaria was in Lagos state. This low frequency of SARS-CoV-2 and malaria co-infections found in our study in Lagos State has also been reported in other studies [17] [24] [25] [26]. The highest co-infection was in Delta State. Even though the exact cause of the observed epidemiological heterogeneity of co-infection of SARS-CoV-2 and malaria amongst the states in Nigeria is unknown, the high rate of SARS-CoV-2 and malaria co-infection in Delta State may be attributed to the presence of pre-existing conditions/co-morbidities like cancer which was observed to be highly prevalent (1647 (57.8%)) among the co-infected participants in Delta State. The immunological mechanisms by which individuals acquire protective immunity or suffer co-infections and comorbidities in Africa are largely unknown [27]. Some factors such as demographics, climate, environment, host genetics, social factors, adherence to public policies/guidelines and others have been suggested to influence co-infection dynamics in Africa [27].

The prevalence of co-infection of SARS-CoV-2 and malaria in the rural area was observed to be higher in Lagos and Sokoto states in this study than in the urban areas. Only Delta state had a reverse prevalence. The adults had the highest co-infection of SARS-CoV-2 and malaria than the children in both Delta and Sokoto States, this corroborates the study carried out in Burkina Faso [19].

As for the symptomatology of coinfections, Delta State had the highest burden of asymptomatic participants among the States, while Lagos had the lowest number of asymptomatic participants. Generally, the study showed few participants with symptoms of SARS-CoV-2 and malaria parasite co-infection. Some authors suggested that patients with SARS-CoV-2 and malaria did not seem to have a worse disease outcome but previous malaria exposure appears to be related to lower frequency of severe COVID-19 [28]. Another study reports that patients co-infected with malaria had a significantly faster recovery compared to those not co-infected [21]. The public health importance of this study is that the coinfection of malaria and COVID-19 in some people may be misdiagnosed and the late diagnosis and differentiation of these two diseases from each other can increase the mortality and complications they cause.

This study showed that there were no comorbidities/pre-existent conditions among the participants in Lagos and Sokoto States with coinfection of malaria and COVID-19 but the wealth quintile is the highest in the middle class in Lagos State while it is high in the lowest class in Sokoto State. When compared to Delta State, the comorbidities/pre-existent conditions that were observed among the participants were diabetes, hypertension, asthma and cancer while the wealth

quintile was observed in the highest class. This is similar to the study carried out by another author [29], which says wealthier people, particularly people from the fourth and highest wealth quintiles, should be careful to avoid unhealthy lifestyles to prevent hypertension, diabetes and cancer.

The limitation of this study was that only RDT kits were used to test the participants for malaria infection and not microscopy. The RDT kits detect both current and old malaria infections due to the antigen-based nature of the RDT.

5. Conclusion

Co-infection of SARS-CoV-2 IgG and malaria was very high in Delta State compared to the other States. The participants in the urban area were more prone to co-infection than the rural area in Delta state only. It is important for clinics to conduct malaria screening to detect possible cases as soon as possible and avoid possible missed diagnoses of COVID-19 co-infections. The infections have similar symptoms and the public is quick to assume they have malaria.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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