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Illness Outcomes of in-and-out Patients Co-infected with SARS-CoV-2 and Malaria, 2020-2022

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Case Report

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Abstract

There is limited of data on the impact of co-infection of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) and malaria on clinical outcomes in Sub-Saharan Africa where malaria is common. We assessed illness outcomes among inpatients presenting with respiratory illness who were infected with SARS-CoV-2 or malaria compared to those infected with both. Data analyzed was collected from the County Referral Hospitals in Nyeri, Marsabit, Kakamega, Nakuru and Siaya, Coast General Hospital, Kenyatta National Hospital and Kakuma refugee camp. These sites are the national sentinel influenza sites, Kenya. SARI was defined as hospitalization with a cough and fever (reported or documented) with 10 days onset, whereas ILI was defined as presentation with cough and measured fever ≥ 38o C with 10 days onset. Severe outcomes were defined as either death, intensive care unit or acute care unit admission, or use of supplemental oxygen. SARS-CoV-2 infection was confirmed through reverse transcription polymerase-chain reaction while malaria infection was confirmed through microscopy. Differences in severe outcomes were assessed using Odds ratios. During the period March 2020 to December 2022, a total of 4889 patients (3986 inpatients and 903 outpatients); of which 3878 (79.3%) were aged <5 years and 2694 (55.1%) males were enrolled. The prevalence of SARS-CoV-2 infections was 7.8 % (381/4889): 6.1% (238/3878) and 13.7% (143/1011) among patients aged <5 and ≥5 years, respectively. Malaria infections were detected in 25.4% (1241/4889) of the patients: 23.7% (919/3878) among children <5 years. Among all patients, co-infections were detected in 1.6% (76/4889) of the patients. Most clinical symptoms were detected from patients with malaria and/or SARS-CoV-2 infection, but SARS-CoV-2 prevalence was higher among old patients and in those with underlying medical conditions. Co-infected inpatients were more likely to die during admission as compared to those infected with malaria alone aOR [13.86 (2.39-9-80.28), p<0.01]. Understanding the effect of SARS-CoV-2 and malaria co-infection is important in advising effective patient management practices.

Keywords: Sars-Cov-2, Covid-19, Oropharyngeal, Hiv/Aids, Nasopharyngeal, Malaria, Pandemic, Viral, Bacterial, Fungal Co-Infections

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Abbrevations

Sarsc-Cov-2: Severe Acute Respiratory Syndrome Coronavirus-2; Iss: Influenza Sentinel Surveillance; Sari: Severe Acute Respiratory Illness; Sos: Surveillance Officers; Ili: Influenza Like Illness; Np: Nasopharyngeal; Ns: Nasal; Op: Oropharyngeal; Vtm: Viral Transport Media; Nic: National Influenza Center; Sgs: School of Graduate Studies; Jooust: Jaramogi Oginga Odinga University of Science and Technology.

Introduction

Severe Acute Respiratory Syndrome-coronavirus 2 (SARS-CoV-2) infection causes the novel coronavirus disease (COVID-19) [1]. Since its outbreak in December 2019 and declaration as a global pandemic, COVID-19 had infected more than 778 million people with over 7 million deaths recorded so far (Https://Covid19.Who.Int/, n.d.). In Africa, over 9.6 million cases and 175,532 deaths had been reported as of June 2025. For Kenya, caseload stood at 344,135 with of 5689 fatalities associated to COVID-19 reported since the first case was identified in March of 2020. In Kenya, over 10,000 deaths associated with malaria are documented each year with Coastal and Western regions having higher caseloads and fatalities with circulation reported throughout the year with seasonal peaks during rainy season [2].

During the COVID-19 pandemic, viral, bacterial, and fungal co-infections were reported with bacterial coinfection being reported as a predictor of mortality [3]. Malaria has been reported in all persons, children less than 5 years, pregnant women, and those with underlying medical conditions such as HIV/AIDs have been shown to be more likely to get affected. Co-infection with COVID-19 and malaria might alter the covid-19 pathophysiology, diseases severity, and clinical outcome. This, however, has not been adequately explored in the Kenyan setting and particularly among individuals presenting with respiratory illnesses.

We characterized illness outcomes among hospitalized patients presenting with respiratory illness who were infected with SARS-CoV-2 and malaria as compared to those infected with malaria or SARS-CoV-2 only.

Methods

Study Sites

There are currently 8 National Influenza sentinel surveillance (ISS) sites in Kenya (Figures 1,2) where patients presenting with respiratory illnesses are enrolled with the exception of Kenyatta National hospital which exclusively enrolls pediatric cases.

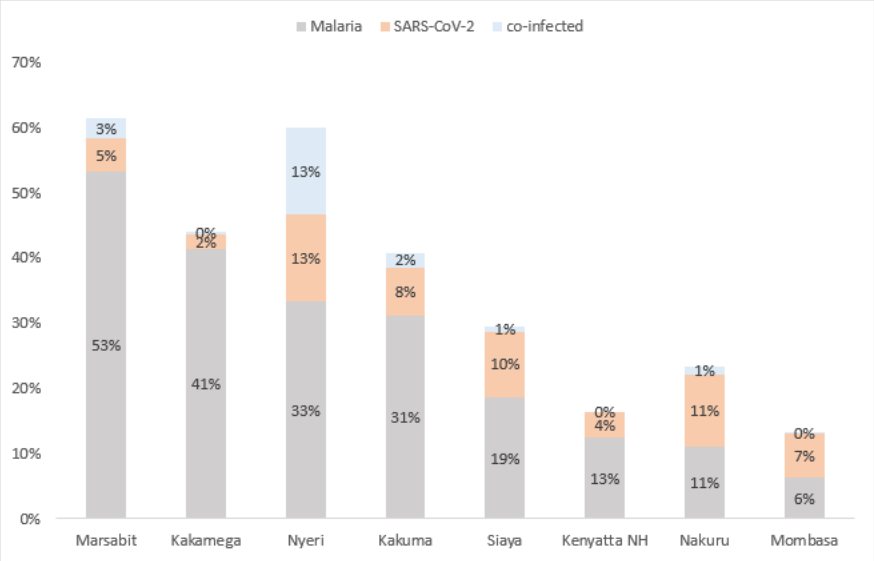

Figure 1: Prevalence of Malaria, SARS-CoV-2 and co-infection by site.

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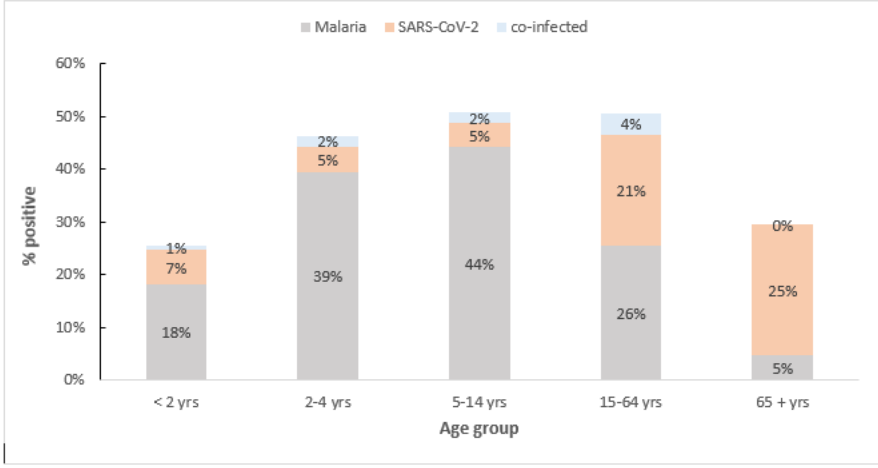

Figure 2: Prevalence of Malaria, SARS-CoV-2 and co-infection by age category.

Study Procedures

Surveillance officers (SOs), either nurse or clinical officer who have been trained on the ISS protocol were involved in identification and enrolment of patients meeting the severe acute respiratory illness (SARI) or influenza like illness (ILI). ILI case was defined using the WHO 2014 [4] case definition as an acute infection with onset within the past 10 days with fever of ≥ 38° C and cough. On the other hand, a SARI case was defined as acute respiratory infection with onset within the last 10 days with fever (measured of ≥ 38° C or subjective/ reported), cough and requiring hospitalization. SARI cases were identified from review of patient's logbooks between Monday to Friday for the seven sites, and up to Saturday for Kakuma site. ILI case identification involved enrolment of the first three cases in a week. The ISS system is currently integrated to allow for surveillance of SARS-CoV-2. In the analysis, we used data collected from ISS platform between March 2020 to December 2022.

Sample Collection and Testing

The nasopharyngeal (NP) or nasal (NS) and/or oropharyngeal (OP) swabs from the enrolled patients were collected by trained SOs. The swabs were then placed in in a single cryovial containing 3mls sterile viral transport media (VTM) then barcoded and labelled with patient unique number and dated. These samples were then stored in temperatures of between 2-8 degrees Celsius and shipped to the National Influenza Center (NIC) for testing and aliquoting. The SARS-CoV-2 testing protocol is described in some published work [4]. A cycle threshold (Ct) of <40.0 was considered positive and negative otherwise. For malaria testing, the tests were by microscopy.

Data Collection

The ISS questionnaire was programmed into password-protected netbooks using Visual studio and MySQL. Trained SOs collected data through the electronic structured question with questions ranging from demographics, clinical symptoms, risk factors including HIV/AIDs, TB, medical history and vaccination status of the patients. At the end of the hospital course, the surveillance officer entered clinical outcomes of the hospitalization from chart reviews. SARS-CoV-2 data were recorded in secured master list in MSQL and merged with the epidemiological data.

Statistical Analysis

Descriptive Analysis

We described patients' characteristics by patient type (inpatient or outpatient) using frequencies and percentages. Microsoft excel charts were plotted to show the proportions of malaria, SARS-CoV-2 and co-infections by site and age categories.

Bivariate analysis was conducted to test association of demographic, respiratory symptoms and risk factors including HIV/AIDs and Tuberculosis with detection of malaria, SARS-CoV-2 or co-detection. Factors associated with severe clinical illness were only assessed among SARI patients stratified by type of detection (malaria, SARS-CoV-2 or both). We defined severe illness to be any of these; oxygen saturation of <90%, death at hospital, admission to ICU/HDU or mechanical ventilation. The patient's age, site and month of data collection were considered a prior and included in the multivariable model to assess disease severity by type of detection. In order to account for possible clustering by

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site and month of onset of illness during to seasonality of respiratory illness, catchment and bed capacities of various facilities as random effects, we ran a mixed regression model. Statistical significance was considered for variables with $p<0.05$. Stata Statistical Software version 16.0 [5] was used for all analyses.

Ethical Consideration

Permission to carry out this study was obtained from the School of Graduate Studies (SGS) of Jaramogi Oginga Odinga University of Science and Technology (JOOUST) and Influenza unit focal person at Mohammed KS, et al. [6]. The parent study was considered a public health activity by KMoH and therefore exempted from ethical review. Clinical information of the study participants was obtained from the study participants by parent study including signed consents. All participants were identified by a unique ID that links their clinical and demographic information without revealing personal identifiers such as names.

Dissemination of Findings

The results from this study will be availed to the University Library and also published in a peer-reviewed scientific journal. Furthermore, the findings will also be presented in public and scientific conferences.

Results

Demographic Characteristics

Table 1 has summaries of patient characteristics. During the period March 2020 to December 2022, a total of 4889 patients from the 8 sentinel influenza surveillance sites in Kenya. In terms of case definition, 3986 (82%) and 903 (18%) were SARI and ILI cases, respectively. Majority (79.4%) of the patients were children aged <5 years. The median age of all the patients was 1.5 years with an interquartile range (IQR): 0.7–4.0). Of these enrolled patients, 2195 (44.9%) were female, and 474 (9.7%) had at least one underlying medical condition (2.0% HIV positive, 2.5% heart disease, 1.9% chronic neurological or neuromuscular disease, 2.1% asthma, 0.4% diabetes, 1.0% other, 1.6% history of tuberculosis). Kakuma site provided the highest percentage of enrolled patients 2320 (47.5%) with the next site reporting many cases being Siaya CRH with 1238 (25.3%). Nyeri CRH had the least number of enrolled patients (0.3%, n=15). Overall, 1413 (28.9%) presented with severe clinical illness (2.3% of outpatients and 34.9% of inpatients). Among outpatients, 1.7% had oxygen saturation <90% and. On the other hand, among inpatients, the proportion presenting with severe clinical illness included 536 (13.5%) who were admitted to the intensive care unit (ICU) or high dependence unit, 225 (5.6%) with oxygen saturation <90%, 172 (4.3%) in-hospital deaths, 47 (1.2%) % who were put on mechanical ventilation during admission (Table 1).

	Outpatients	Inpatients	All
	n=903	n=3986	n=4889
Age in years, median (IQR)	5.1 (1.6-22.9)	1.2 (0.6-2.9)	1.5 (0.7-4.0)
< 2 years	225 (28.2)	2594 (65.1)	2849 (58.3)
2-4 years	183 (20.3)	846 (21.2)	1029 (21.1)
5-14 years	162 (17.9)	278 (7.0)	440 (9.0)
15-64 years	292 (32.3)	194 (4.9)	486 (9.9)
≥65 years	11 (1.2)	74 (1.9)	85 (1.7)
Female, n (%)	445 (49.3)	1750 (43.9)	2195 (44.9)
Site name, n (%)			
Kenyatta NH	0 (0.0)	104 (2.6)	104 (2.1)
Mombsasa CRH	23 (2.6)	567 (14.2)	590 (12.1)
Nyeri CRH	4 (0.4)	11 (0.3)	15 (0.3)
Nakuru CRH	0 (0.0)	171 (4.3)	171 (3.5)
Kakamega CRH	12 (1.3)	208 (5.2)	220 (4.5)
Siaya CRH	271 (30.0)	967 (24.3)	1238 (25.3)
Marsabit CRH	127 (14.1)	104 (2.6)	231 (4.7)
Kakuma	466 (51.6)	1854 (46.5)	2320 (47.5)

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Had an underlying medical condition, n (%)	72 (8.0)	402 (10.1)	474 (9.7)
HIV-infected	18 (2.0)	79 (2.0)	97 (2.0)
History of tuberculosis	12 (1.3)	65 (1.6)	77 (1.6)
Heart disease	13 (1.4)	108 (2.7)	121 (2.5)
Chronic neurological or neuromuscular disease	5 (0.6)	87 (2.2)	92 (1.9)
Asthma	24 (2.7)	76 (1.9)	100 (2.1)
Diabetes	4 (0.4)	16 (0.4)	20 (0.4)
Othera	6 (0.7)	43 (1.1)	49 (1.0)
Hospitalized in the past 12 months, n (%)	34 (3.8)	391 (9.8)	425 (8.7)
SARS-CoV-2 positive, n (%)	105 (11.6)	276 (6.9)	381 (7.8)
<5 yrs	21 (4.8)	217 (6.3)	238 (6.1)
≥ 5 yrs	84 (18.1)	59 (10.8)	143 (14.1)
Malaria positive	444 (49.2)	797 (20.0)	1241 (25.4)
< 5 yrs	244 (55.7)	675 (23.7)	919 (23.7)
≥ 5 yrs	200 (43.0)	122 (22.3)	322 (31.9)
Co-infected with SARS-CoV-2 and Malaria	36 (4.0)	40 (1.0)	76 (1.6)
< 5 yrs	10 (2.3)	38 (1.1)	48 (1.2)
Severe clinical illness (n, %)b	21 (2.3)	1392 (34.9)	1413 (28.9)
Oxygen saturation <90%	15 (1.7)	225 (5.6)	240 (4.9)
In-hospital death	N/A	172 (4.3)	172 (3.5)
Admission to ICU/IDU	N/A	536 (13.5)	536 (11.0)
Mechanical ventilation during admission	N/A	47 (1.2)	47 (1.0)
Supplementary oxygen	N/A	1149 (28.8)	1149 (23.5)

Table 1: Characteristics of the Study Population at Enrollment in Kenya, Mar 2020 to Dec 2022.

Malaria And SARS-Cov-2 Co-Detection

A total of 381 (7.8%) tested positive for SARS-CoV-2 (105 (11.6%) among outpatients and 276 (6.5%) from inpatients). In terms of age categories, 238 (6.1%) children under 5 years tested positive for the virus while 143 (14.1%) of those five years and above tested positive for SARS-CoV-2. On the other hand, malaria was detected among 919 (23.7%) of children under five years (55.7% and 23.7% among under five-year olds seen in outpatient and inpatient clinics, respectively. Malaria and SARS-CoV-2 co-infected was detected in 76 (1.6%) of all the patients and in 48 (1.2%) among patients aged below five years.

Malaria and SARS-CoV-2 were detected across the sites throughout the study period. However, comparatively low prevalence of SARS-CoV-2 was observed in sites with high malaria prevalence for instance 53% vs 5% in Marsabit, 41% vs 2% in Kakamega. Conversely, for sites with comparatively higher prevalence of SARS-CoV-2, lower malaria prevalence was observed for example Kenyatta NH 13% vs 4%. Further, as regards age groups, under 5-year-olds had malaria versus SARS-CoV-2 prevalence of 57% vs 12% as compared to 65+ year-olds with prevalence of 5% vs 25% (are these significant?).

Factors Associated with Malaria and Sars-Cov-2 Infection Detection

The prevalence of malaria was significantly higher in patients aged <5 years a ($p<0.001$), those who presented to the facility with headache ($p<0.001$), chills ($p<0.001$), sore throat ($p<0.001$), abdominal pain ($p=0.004$) and those with loss of taste ($p<0.001$). Furthermore, these patients also convulsed ($p<0.001$) and had sore muscles ($p<0.001$). Similarly, SARS-CoV-2 virus was detected among patients who had difficulty in breathing ($p<0.001$), muscle or joint pains ($p<0.001$), headache ($p<0.001$), chills ($p<0.001$), sore

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muscles (p<0.001) as well as abdominal pain (p<0.001).

Higher SARS-CoV-2 virus detection percentages were also observed among patients aged 15-64 years. Further, those with any underlying medical condition, p<0.001 and for conditions such as HIV/AIDs (p=0.019), Heart disease (p<0.001), Chronic neurological or neuromuscular disease (p<0.001), Asthma (p<0.001) and other (liver, renal and cancer diseases), p<0.001. On other hand, patients co-infected with malaria and SARS-CoV-2 were significantly younger (< 5 yrs), p<0.001 and mostly presented with muscle or joint pains (p=0.039), headache (p<0.001). In addition, other clinical symptoms that showed significant presence in co-infected participants were chills (p=0.012), sore throat (p=0.035), runny nose (p=0.008) and sore muscles (p=0.015).

Factors Associated with Severe Clinical Illness Among Sari Patients with Malaria or Sars-Cov-2 Infection

Among 1033 SARI patients who tested positive for malaria , SARS-CoV-2 or both, odds of severe disease were compared among the three detection types. There were increased odds of death among those co-infected as compared to those infected with malaria alone (aOR=13.86, 95% CI [2.39,80.28]). On the other hand, there was no significant difference in the odds of severe disease among those co-infected as compared to those infected with SARS-CoV-2 only, (aOR=0.37, 95% CI [0.12-1.19]). Though, insignificant , there was increased odds of death among patients co-infected as compared to those who were infected with SARS-CoV-2 only (aOR=2.39, 95% CI [0.58,9.93]) (Table 2,3)

	Malaria only	p-value	SAR-CoV-2 only	p-value	Co-infection	p-value
	n=1241		n=381		n=76	
Clinical Symptoms						
Chest pain on breathing	164 (13.2)	0.53	79 (20.7)	<0.001	13 (17.1)	0.245
Muscle/joint pains	153 (12.3)	0.332	104 (27.3)	<0.001	16 (21.1)	0.039
Headache	240 (19.3)	<0.001	62 (16.3)	<0.001	24 (31.6)	<0.001
Vomiting	569 (45.9)	0.065	144 (37.8)	0.017	37 (48.7)	0.368
Chills	547 (44.1)	<0.001	174 (45.7)	<0.001	38 (50.0)	0.012
Sore throat	145 (11.7)	0.017	74 (19.4)	<0.001	13 (17.1)	0.035
Runny nose	758 (61.1)	0.064	239 (62.7)	0.109	56 (73.7)	0.008
Wheezing	49 (4.0)	<0.001	34 (8.9)	0.911	1 (1.3)	0.018
Abnormal breath sounds	189 (15.2)	<0.001	112 (29.4)	0.132	12 (15.8)	0.038
Unusual bleeding	24 (1.9)	0.071	4 (1.1)	0.533	1 (1.3)	0.943
Skin rash	38 (3.1)	0.006	12 (3.2)	0.197	1 (1.3)	0.181
Abdominal pain	153 (12.3)	0.004	63 (16.5)	<0.001	11 (14.5)	0.213
Sore muscles	97 (7.8)	<0.001	25 (6.6)	0.355	9 (11.8)	0.015
Difficulty in breathing	558 (45.0)	<0.001	238 (62.5)	0.573	31 (40.8)	<0.001
Loss of appetite	582 (46.9)	<0.001	158 (41.5)	0.746	35 (46.1)	0.5
Convulsions	222 (17.9)	0.026	51 (13.4)	0.163	10 (13.2)	0.511
Diarrhea	123 (9.9)	<0.001	48 (12.6)	0.235	5 (6.6)	0.045
For patients < 5 years						
Unable to drink or breastfeed	50 (5.4)	<0.001	17 (7.1)	0.347	1 (2.1)	0.098
Vomits everything	74 (8.1)	0.118	10 (4.2)	0.089	4 (8.3)	0.696
Nasal flaring	104 (11.3)	<0.001	60 (25.2)	0.582	5 (10.4)	0.01
Stridor	96 (10.5)	0.469	15 (6.3)	0.06	4 (8.3)	0.727
Grunting	44 (4.8)	<0.001	15 (6.3)	0.099	1 (2.1)	0.083
Chest-in-drawing	196 (21.3)	<0.001	112 (47.1)	0.217	11 (22.9)	0.004
Lethargy	369 (40.2)	0.814	107 (45.0)	0.147	22 (45.8)	0.447

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Unconscious	7 (0.8)	0.041	4 (1.7)	0.78	0 (0.0)	0.395
Signs on examination						
Had an underlying medical condition, n(%)	43 (3.5)	<0.001	63 (16.5)	<0.001	2 (2.6)	0.036
HIV-infected	9 (0.7)	<0.001	13 (4.9)	0.019	0 (0.0)	0.176
History of tuberculosis	11 (0.9)	0.023	8 (2.1)	0.381	0 (0.0)	0.266
Heart disease	6 (0.5)	<0.001	22 (5.8)	<0.001	0 (0.0)	0.162
Chronic neurological or neuromuscular disease	8 (0.6)	<0.001	13 (3.4)	0.022	1 (1.3)	0.714
Asthma	5 (0.4)	0.045	5 (6.6)	0.566	0 (0.0)	0.204
Diabetes	0 (0.0)	0.009	7 (1.8)	<0.001	0 (0.0)	0.573
Other[a]	5 (0.4)	0.014	11 (2.9)	<0.001	1 (1.3)	0.782

Table 2: Predictors of Malaria and SARS-CoV-2 infections in Kenya, Mar 2020 to Dec 2022.

	Malaria positive only n(%)	**SARS-CoV-2 positive only n(%)**	**Co-infected n (%)**	**Adjusted[a] Risk ratio (95% CI)**	**Adjusted[b] Risk ratio (95% CI)**
	n=757	**n=236**	**n=40**		
Severe clinical illness (n,%)[c]	170 (22.5)	94 (39.8)	5 (12.5)	0.87 (0.30-2.54)	0.37 (0.12-1.19)
Oxygen saturation <90%	25 (3.3)	20 (8.5)	1 (2.5)	1.82 (0.20-16.52)	0.68 (0.08-6.00)
In-hospital death	8 (1.1)	19 (8.1)	3 (7.5)	**13.86 (2.39-9-80.28)**	2.39 (0.58-9.93)
Admission to ICU/IDU	106 (14.0)	29 (12.3)	2 (5.0)	0.74 (0.11-4.84)	0.88 (0.11-6.25)
Mechanical ventilation during admission	5 (0.7)	2 (0.9)	0 (0.0)	NE	NE
Supplementary oxygen	97 (12.8)	82 (34.8)	3 (7.5)	0.72 (0.21-2.53)	0.32 (0.08-1.19)

[a]Adjusted for age, gender, presence of chronic illness, month (re) and site (re)

[a]Adjusted for age , gender, presence of chronic illness, month (re) and site (re)

Table 3: Severe Outcomes Associated with SARS-Cov-2 and Malaria Co-Infection in Kenya Among SARI Patients, Mar 2020 To Dec 2022.

Discussion

In this study, it was observed that malaria and SARS-CoV-2 continued to circulate in Kenya throughout the SARS-CoV-2 pandemic across the 8 surveillance sites. Further, it was established sites with higher prevalence of malaria reported lower proportions of SARS-CoV-2 infections. This analysis further revealed that patients infected with either of these two pathogens presented with similar clinical symptoms but there were marked differences with age with older patients and those with comorbidities at greater risk of SARS-CoV-2 infections. Additionally, co-infected patients had increased odds of death as compared to those infected with malaria only.

Several studies have shown that malaria continued to circulate during the Covid-19 pandemic in the period 2020 to the year 2022. Our results show that like other Countries, malaria continued to be reported during the pandemic. Some experts have attributed this to that fact that intervention strategies for these two pathogens are different and thus, the introduction of the Covid-19 mitigation measures could have worked minimally to reduce the spread of malaria. Although, our study is limited in explaining the reason for rather constant prevalence of malaria during the pandemic even though the health system has been reported to have experienced disruptions due to the pandemic, our findings highlight the utility of local surveillance and need for diagnosis and care of co-infected and those with lone infection presenting with almost similar symptoms.

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In addition, on the strain on health care systems, another major concern is the potential for malaria and SARS-CoV-2 co-circulation and the risk of severe disease resulting from this. Although this study attempts to assess the extent of and the impact of this co-circulation, this is still an evolving topic. Based on work from a few studies, there have been a varying range of prevalence of SARS-CoV-2. For instance, prevalence of malaria co-infection in people with SARS-CoV-2 has been recorded as (0.8%) in India [7,8] and 6.3% among health care workers. In this study, we found 19.9 % (63/768) malaria co-infection in participants who tested positive for SARS-CoV-2 in our study sample. Unlike previous findings from India, but consistent with findings from [9], we found increased odds of death among patients co-infected with malaria and SARS-CoV-2 as compared to those with malaria alone. These findings together with the existing literature on malaria and SARS-CoV-2 co-infection indicate the need for monitoring of these infections to inform preventive and management care.

It has been established that there are certain factors associated with increased severe malaria outcomes, such as age (under 5 years), pregnant women and those with underlying medical conditions including HIV/AIDs [10]. Likewise, individuals aged at least 65 years and those with chronic medical conditions are at increased risk of severe Covid-19 disease [11]. In this study, there were high proportion of malaria infections among patients <5 years and over 30% SARS-CoV-2 infections and 25% co-infections among individuals 15 years and above. Similarly, more than 15% SARS-CoV-2 infections were had underlying medical conditions. The results might have concealed age difference in detection with as some of the ages were lumped together because of the small sample size. Therefore, studies with large sample sizes will be able to reveal the difference in detection and severity of SARS-CoV-2 infection with age.

The association between other SARS viruses such as MERSCOV and childhood infections and its severity has been reported in the literature. In Kenya, malaria has been found to be the predominant risk factor of post-discharge mortality among children admitted with respiratory conditions Together with existing literature on disease severity, these findings could guide clinicians in patients' management especially in malaria endemic settings and with underlying chronic conditions such as HIV/AIDs.

Limitations

Though this study utilized data for a strong Influenza surveillance system collecting data from all ages and effort was made to control potential confounders, there were some limitations. The Influenza system was not powered for malaria surveillance though because its robustness and geographical reach, the output is representative of Kenyan setting. Further, severe clinical illnesses were defined by presentations at the hospital and didn't include hospital outcomes after discharge.

More studies are therefore warranted to understand disease severity among patients co-infected with malaria and SARS-CoV-2. Despite the aforementioned limitations, these findings have significant implications for public health and policy decisions [12].

Conclusion

Malaria and SARS-CoV-2 continued to co-circulate in Kenya during the Covid-19 pandemic posing further challenges to a health care system grappling with chronic diseases such as Tuberculosis and HIV/AIDs. Even though, the mandate of the Influenza surveillance system is not to track malaria infections, the platform is robust enough to give significant overview of the Kenyan set up. Therefore, the findings demonstrate the need to implement or strengthen national sentinel surveillance systems and/or expand these systems to allow monitoring respiratory illnesses and other diseases of public health concern. In addition, these finsings show usage of surveillance to identify risk factors and disease progresssion in the event of co-circulation. These findings could be utilized to improve health literacy and diagnosis and severity of both illnesses through risk communication as well advocate for malaria and COVID-19 vaccinations.

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