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Factors associated with laboratory-confirmed SARS-Cov-2 infection among patients with severe respiratory illness (SRI): Findings from the COVID-19 vaccine effectiveness evaluation in Kenya and Mali, 2022–2023☆

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ABSTRACT

Background: Understanding the epidemiology of SARS-CoV-2 infection in settings with limited data, especially given the dynamic nature of the virus and the reported epidemiological heterogeneity across countries, is important. We used data from the COVID-19 Vaccine effectiveness evaluation to determine factors associated with SARS-COV-2 infection among patients (≥ 12 years) with severe respiratory illness (SRI) in Kenya and Mali.
Methods: SRI was defined as acute onset (≤ 14 days) of at least two of the following: cough, fever, chills, rigors, myalgia, headache, sore throat, fatigue, congestion or runny nose, loss of taste or smell, or pneumonia diagnosis. We collected demographic and clinical characteristics of the patients, and nasopharyngeal and oropharyngeal specimens for SARS-CoV-2 testing using RT-PCR. We used a mixed effect logistic regression to determine factors associated with SARS-CoV-2 infection adjusting for age and sex while controlling for clustering by site and month of illness onset.
Results: Between July 2022 and October 2023, a total of 9941 patients with SRI were enrolled, of whom, 588 (5.9 %) tested positive for SARS-CoV-2. Compared to patients aged 12–24 years, those who were aged >64 years were more likely to have SARS-CoV-2 infection (adjusted Odds Ratio [aOR] = 1.60; 95 % Confidence Interval [95 % CI] 1.07–2.40). Additionally, SRI patients presenting with cough (aOR = 1.37; 95 % Confidence Interval [95 %

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CI] 1.05–1.80), sore throat (aOR = 1.56; 95 % CI 1.23–1.99), runny nose (aOR = 1.51; 95 % CI 1.18–1.94), and ear pain discharge (aOR = 2.58; 95 % CI 1.43–4.66) were more likely to have SARS-CoV-2 infection compared to those who did not. SRI patients who had HIV were also more likely to have SAR-CoV-2 infection compared to those who did not (aOR =1.32; 95 % CI 1.04–1.67).

Conclusion: Older adults and HIV patients were at increased-risk of SARS-CoV-2 infection consistent with WHO guidelines highlighting the need for targeted prevention and management strategies focused on them.

1. Introduction

The novel coronavirus, "severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)", causes a highly contagious infection called coronavirus disease 2019 (COVID-19), which the World Health Organization (WHO) declared a pandemic in March 2020 [1]. As of 18th August 2024, over 775 million confirmed cases of COVID-19 and more than seven million deaths were reported globally to the WHO [2]. Kenya detected its first case of COVID-19 in March 13, 2020, shortly after the WHO declaration while on 25 March 2020 Mali confirmed its first two COVID-19 [3]. As of August 18, 2024, Kenya had reported 344,109 cases and 5689 deaths whereas Mali had reported 33,166 confirmed cases and 743 deaths [3]. Despite the WHO declaring the end of global pandemic on 5 May 2023, the virus remains a global health threat [4].

Several studies have characterized the risk factors of SARS-CoV-2 among patients with severe respiratory illness (SRI) globally, in Africa and in Kenya. Despite these efforts, substantial differences in the epidemiology of SARS-CoV-2 have been reported between countries in Africa [5]. Furthermore, previous studies in Kenya [6,7] were conducted earlier in the pandemic but SARS-CoV-2 has been evolving over time with various variants having differing transmissibility, severity and other clinical presentation emerging [8,9]. Additionally, the above mentioned studies in Kenya were conducted in Nairobi and Mombasa and therefore lacked national representation. While in Mali there is limited research on predictors of SARS-CoV-2 infection, with existing studies focusing on seroprevalence [10,11]. Understanding the epidemiology and risk factors for SARS-CoV-2 infection in settings with limited data such as Kenya and Mali is crucial, especially given the virus's evolving characteristic partly due to emerging variants and the absence of nationally representative studies. Such efforts could help inform targeted interventions for improvement in clinical management and to inform policy decisions. We used data from a COVID-19 vaccine evaluation to characterize factors associated with SARS-CoV-2 infection among patients with SRI in Kenya and Mali.

2. Methods

2.1. Definition of key terms and variables

Severe Respiratory Illness (SRI): A patient aged ≥12 years who was hospitalized or recommended for hospitalization by a clinician AND had acute respiratory illness (onset ≤14 days) of at least two of the following: cough, fever (reported or measured temperature of ≥38 °C), chills, rigors, myalgia, headache, sore throat, fatigue, congestion or runny nose, loss of taste or smell, OR pneumonia based on clinical diagnosis or chest x-ray.

2.2. Study setting and population

Kenya Medical Research Institute (KEMRI) in partnership with Center for Vaccine development (CVD) Mali collaborated with their respective ministry of health, WHO, Washington State University (WSU) and the US Centers for Disease Control and Prevention (CDC) to set up the COVID-19 vaccine effectiveness evaluation (CVE) in Kenya and Mali. In Kenya, this study was conducted at one national referral hospital and 19 other County Referral Hospitals representing the larger part of the Kenyan population (Fig. 1). In Mali, CVD operated the study in 12 sentinel health facilities in Bamako capital city (4 hospitals and 8 Referral Health centers) (Fig. 1). All these sites were COVID detection centers and represent the main referral structures in Mali. Referral Health center is the second level in the Mali health pyramid after community health centers. Hospitals had capacity to manage very severe cases with oxygen and emergency equipment. The study population included patients aged ≥12 seeking care for SRI from the general Kenyan and Malian population. In Kenya, recruitment took place from July 2022 to August 2023, whereas in Mali, it spanned from November 2022 to October 2023.

2.3. Study design

This was a hospital based study nested within the COVID-19 vaccine

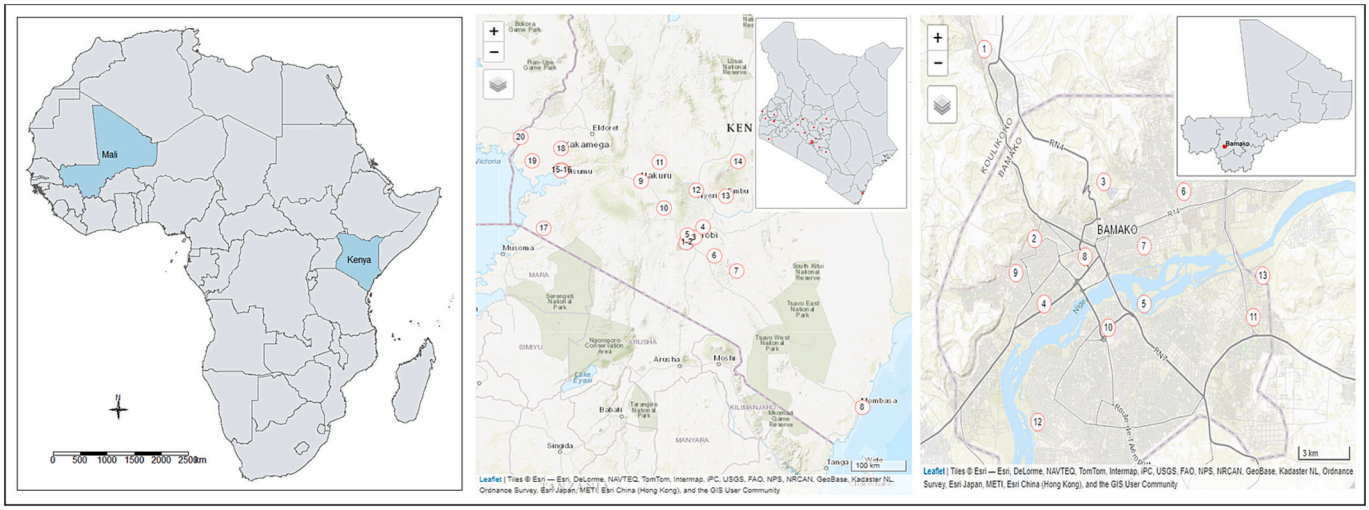

Fig. 1. Map showing the Covid-19 Vaccine Evaluation sites in Kenya and Mali, July 2022–October 2023.

evaluation (CVE) in Kenya and Mali. We compared SRI patients who tested positive to those who tested negative for SARS-CoV-2.

2.4. Data collection

Trained clinical officers screened patients seeking care for SRI at out/in patient and special clinics within the sentinel facilities. Those who met SRI case definition and provided NP/OP specimen were subsequently enrolled. Socio-demographic and clinical information were collected using a standardized questionnaire programed in a window surface Go2 tablets. Patient illness records and outcome data were abstracted from patient files or electronic medical records at discharge. Mali data was collected on Tablets using REDCap software. Data were transmitted via a Virtual Private Network (VPN) provided by selected service providers in Kenya and Mali to a secure, password-protected central database hosted on servers located at the KEMRI and CVD offices in Kisumu, Kenya, and Bamako, Mali respectively.

Regular supportive supervisory visits were carried out at the Kenyan sites to monitor the execution of recruitment, clinical activities, laboratory processes, and data collection procedures in accordance with the protocol. Additionally, routine data quality assessment were conducted by the study statistician.

2.5. Specimen collection, transportation and storage

Nasopharyngeal (NP) and oropharyngeal (OP) specimens were collected within 48 h of presentation/admission from participants according to CDC Guidelines for Collecting and Handling of Clinical Specimens for COVID-19 Testing [12]. In brief, NP swabs were collected using a fine tipped polyester aluminum shaft swab while OP swabs were collected using a dacron plastic shaft swab. For each patient, both swabs were placed in a single cryovial with viral transport media (VTM) and refrigerated or stored in cool boxes at temperatures ranging from 2 to 8 °C then transported to the KEMRI/CVD laboratories where they were frozen immediately at -80 °C until testing or tested for RT-PCR and then aliquoted and stored at -80 °C.

2.6. Specimen testing

At the KEMRI and CVD-Mali laboratories, specimens were tested using real-time polymerase chain reaction (RT-PCR) and a cycles threshold (C_T) <40 was considered positive for SARS-CoV-2 while $C_T \geq 40$ was considered negative for SARS-CoV-2.

2.7. Statistical analysis

The outcome variable of interest in this study was laboratory-confirmed SARS-CoV-2 infection. We compared characteristics of SRI patients who tested positive for SARS-CoV-2 by RT-PCR to those who tested negative. The data were summarized by using counts and percentages for categorical variables, while median and interquartile range, were used for continuous variables. We compared categorical variables using Pearson's chi-square or Fishers Exact test where appropriate. Wilcoxon rank-sum tests were used to compare continuous variables based on their distribution. We assessed for collinearity across variables using Cramer's V statistic and when present only variables with the strongest association with SARS-CoV-2 infection were kept in the multivariable model [13]. Variables with a significance level of $p < 0.2$ in the bivariate logistic regression were included in the multivariable model. A mixed-effects multivariable logistic regression model was fitted to identify factors associated with laboratory-confirmed SARS-CoV-2 infection among patients with SRI. This model accounted for clustering in the study sentinel health facilities and calendar time (month of illness onset). Age-group and sex were included in the model a priori. Collinearity of variables in the final multivariable model was further assessed using the generalized variance inflating factors [14].

We reported adjusted Odds ratios (aOR) and their 95 % confidence intervals (95 % CI) from the final model with variables having a p-value <0.05 considered as significantly associated with SARS-CoV-2 infection. R software, version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria) was used to perform all statistical analyses.

2.8. Ethical considerations

The current study was part of CVE protocol which was reviewed and approved by the KEMRI Scientific and Ethics Review Unit (KEMRI SERU #-4433), the US CDC, and WHO (Protocol ID: AFR/ERC/2021/5.3.), as well as the Faculty of Medicine and Odonto-Stomatology (FMOS) in Mali (#4433). Reliance was also obtained from the Washington State University Institutional Review Board (WSU IRB). All sentinel health facilities provided administrative approval for the protocol before implementation. Written informed consent was obtained from each participant, next of kin or caretaker before their participation.

3. Results

3.1. Demographic and clinical characteristics

Between July 2022 and October 2023, a total of 9951 patients with SRI were enrolled in the study and 10 (0.1 %) who did not produce NPOP specimen were excluded from this analysis. Of 9941 included in the analysis, 588 (5.9 %) tested positive for SARS-CoV-2, while 9353 (94.1 %) were negative (Fig. 2). Among the participants, 8018 (80.7 %) were from Kenya, and 1923 (19.3 %) were from Mali, with a significantly higher prevalence of SARS-CoV-2 positivity in Kenya (551/8018 [6.9 %]) compared to Mali (37/1923 [1.9 %], $p < 0.001$). Participants in Kenya were older than their counterparts in Mali (median age in years [interquartile range: 45 [32–65] vs 41 [28–60], p < 0.001). We observed significant differences in the characteristics of participants in Kenya and Mali across all variables except for ear pain/discharge, skin rash, conjunctivitis, convulsions, neuromuscular disease and hypertension ($p < 0.05$) (Table S1).

Occupation, sore throat, diarrhea, rigors, runny nose, HIV, and pharyngeal exudate were positively associated with SARS-CoV-2 infection at bivariate analysis. Conversely, sore muscles were less common among those who tested positive (27.3 % vs. 33 %, $p = 0.004$) (Table 1).

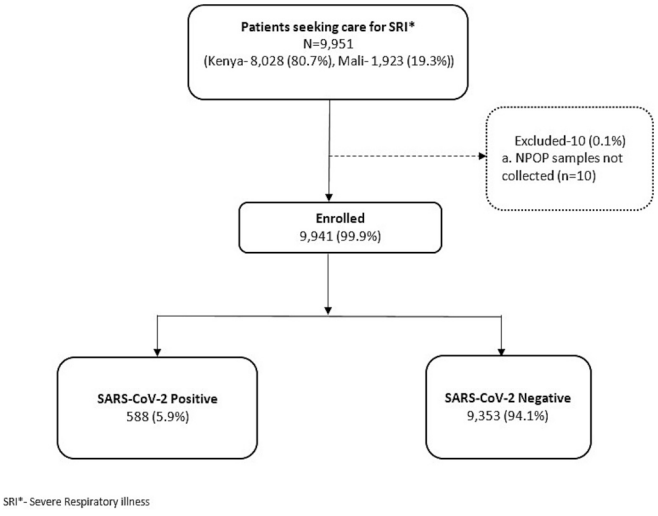

Fig. 2. Flowchart of SARS-CoV-2 infection among patients with severe respiratory illness in Kenya and Mali: July 2022–October 2023.

Table 1
Patient characteristics stratified by SARS-CoV-2 status among patients with severe respiratory illness in Kenya and Mali- July 2022-October 2023.

Demographic characteristics	Category	All participants (n = 9941)	SARS-CoV-2 Positive (n = 588)	SARS-CoV-2 Negative (n = 9353)	p-value
		n (%)	n (%)	n (%)	
Country	Kenya	8018 (80.7)	551 (93.7)	7467 (79.8)	<0.001
	Mali	1923 (19.3)	37 (6.3)	1886 (20.2)	
Age Category (years)	12–24	1365 (13.7)	60 (10.2)	1305 (14)	0.033
	25–34	1711 (17.2)	122 (20.7)	1589 (17)	
	35–44	1840 (18.5)	102 (17.3)	1738 (18.6)	
	45–54	1412 (14.2)	77 (13.1)	1335 (14.3)	
	55–64	1194 (12)	76 (12.9)	1118 (12)	
	>64	2419 (24.3)	151 (25.7)	2268 (24.2)	
Age Years	Median [Q1-Q3]	45 [31–64]	45 [33–65]	45 [31–64]	0.252
Gender	Male	5036 (50.7)	277 (47.1)	4759 (50.9)	0.083
Occupation	Formal Employment	1073 (10.8)	94 (16)	979 (10.5)	<0.001
	Self-employed	3012 (30.3)	187 (31.8)	2825 (30.2)	
	Not employed	4038 (40.6)	251 (42.7)	3787 (40.5)	
	Student	928 (9.3)	39 (6.6)	889 (9.5)	
	Part-time employment	83 (0.8)	0 (0)	83 (0.9)	
	Others	807 (8.1)	17 (2.9)	790 (8.4)	
Respiration rate (>20), n = 9934	Yes	5492 (55.3)	5164 (55.3)	328 (55.8)	0.836
Oxygen saturation (<90), n = 9904	Yes	2196 (22.2)	2050 (22)	146 (24.8)	0.122
Headache, n = 9933	Yes	5627 (56.6)	5310 (56.8)	317 (53.9)	0.181
Fever, n = 9900	Yes	3767 (38.1)	3548 (38.1)	219 (37.4)	0.760
Cough, n = 9939	Yes	8364 (84.2)	7856 (84)	508 (86.4)	0.140
Chills, n = 9936	Yes	3886 (39.1)	3676 (39.3)	210 (35.7)	0.090
Rigors, n = 9923	Yes	1049 (10.6)	967 (10.4)	82 (13.9)	0.008
Sore throat, n = 9937	Yes	1982 (19.9)	1836 (19.6)	146 (24.9)	0.003
Diarrhea, n = 9905	Yes	829 (8.4)	764 (8.2)	65 (11.2)	0.014
Vomiting, n = 9929	Yes	1584 (16)	1483 (15.9)	101 (17.2)	0.437
Sore muscles, n = 9917	Yes	3242 (32.7)	3082 (33)	160 (27.3)	0.004
Fatigue/malaise, n = 9938	Yes	7114 (71.6)	6709 (71.8)	405 (68.9)	0.146
Congestion, n = 9940	Yes	1650 (16.6)	1542 (16.5)	108 (18.4)	0.258
Runny nose, n = 9929	Yes	1988 (20)	1843 (19.7)	145 (24.7)	0.005
Loss of taste/smell, n = 9935	Yes	2129 (21.4)	2002 (21.4)	127 (21.6)	0.959
Abnormal sounds, n = 9920	Yes	4504 (45.4)	4229 (45.3)	275 (46.8)	0.495
Difficulty in breathing, n = 9938	Yes	5944 (59.8)	5574 (59.6)	370 (63)	0.110
Haemoptysis	Yes	577 (6.8)	39 (7.7)	538 (6.8)	0.479
Ear pain/discharge	Yes	128 (1.3)	16 (2.7)	112 (1.2)	0.003
Skin rash, n = 9929	Yes	180 (1.8)	169 (1.8)	11 (1.9)	1.000
Conjuctivitis, n = 9932	Yes	157 (1.6)	148 (1.6)	9 (1.5)	1.000
Convulsions, n = 9924	Yes	262 (2.6)	248 (2.7)	14 (2.4)	0.797
Irritability/Confusion	Yes	789 (8)	49 (8.3)	740 (7.9)	0.782
Neuromuscular disease, n = 9924	Yes	1179 (11.9)	1136 (12.2)	43 (7.3)	0.001
coma, n = 9920	Yes	153 (1.5)	146 (1.6)	7 (1.2)	0.588
HIV, n = 9888	Yes	1585 (16)	1467 (15.8)	118 (20.3)	0.006
Neuromuscular disease, n = 9927	Yes	173 (1.7)	167 (1.8)	6 (1.0)	0.227
TB	Yes	818 (8.2)	776 (8.3)	42 (7.1)	0.363
Heart Disease, n = 9913	Yes	735 (7.4)	688 (7.4)	47 (8)	0.620
Malnutrition	Yes	252 (2.5)	239 (2.6)	13 (2.2)	0.704
Liver Disease, n = 9921	Yes	123 (1.2)	115 (1.2)	8 (1.4)	0.936
Diabetes	Yes	885 (8.9)	830 (8.9)	55 (9.4)	0.748
Hypertension	Yes	2040 (20.5)	1914 (20.5)	126 (21.4)	0.611
Asthma, n = 9941	Yes	520 (5.2)	498 (5.3)	22 (3.7)	0.115
Cancer, n = 9911	Yes	190 (1.9)	180 (1.9)	10 (1.7)	0.815
Sickle cell, n = 9924	Yes	76 (0.8)	75 (0.8)	1 (0.2)	0.134
Time to care-seeking (days)	Median [Q1-Q3]	4 [2–7]	4 [2–7]	4 [2–7]	0.798

3.2. Factors associated with SARS-CoV-2 infection

We did not observe differences in age between patients who were SARS-CoV-2 positive and those who were negative (Median age in years [IQR]: 45 [33–65] vs 45 [31–64], p = 0.252). Furthermore, in the final multivariable model, participants over 64 years of age (aOR = 1.60, 95 % CI 1.07–2.40) were more likely to have SARS-CoV-2 infection compared to those aged 12–24 while male patients were less likely to have SARS-CoV-2 infection than females (aOR = 0.81, 95 % CI 0.68–0.98). Moreover, symptoms such as sore throat (adjusted Odds Ratio [aOR] = 1.56, 95 % confidence interval [95 % CI] 1.23–1.99), cough (aOR = 1.37, 95 % CI 1.05–1.80), runny nose (aOR = 1.51, 95 % CI 1.18–1.94), ear pain or discharge (aOR = 2.58, 95 % CI 1.43–4.66) and HIV (aOR = 1.32, 95 % CI 1.04–1.67) were associated with SARS-CoV-2 infection. Additionally, compared to those in formal employment, those who were self-employed (aOR = 0.73; 95 % CI 0.55–0.97), unemployed (aOR = 0.69, 95 % CI 0.51–0.93) or students (aOR = 0.60, 95 % CI 0.37–0.98) were less likely to have SARS-CoV-2 infection (Table 2).

4. Discussion

To the best of our knowledge, this is the first and largest ever conducted evaluation of risk factors for laboratory-confirmed SARS-CoV-2 infections among patients with SRI in Kenya and Mali. Our study found that SRI patients aged over 64 years old were more likely to have laboratory confirmed SARS-CoV-2 infection than younger patients. Male patients were less likely to have SARS-CoV-2 infection. Furthermore, we observed that the following clinical symptoms were associated with SARS-CoV-2 infection: sore throat, runny nose and ear pain/discharge.

Table 2
Factors associated with SARS-CoV-2 infection among patients with severe respiratory illness in Kenya and Mali- July 2022-October 2023.

Characteristics	Category	Bivariate OR (95 %CI)	Multivariable aOR (95 % CI)*	p-value
Age Category (years)	12–24	Ref	**Ref**	
	25–34	**1.67 [1.22–2.29]**	1.39 [0.94–2.05]	0.099
	35–44	1.28 [0.92–1.77]	1.04 [0.69–1.57]	0.845
	45–54	1.25 [0.89–1.77]	1.11 [0.73–1.71]	0.620
	55–64	**1.48 [1.04–2.09]**	1.48 [0.96–2.28]	0.073
	>64	**1.45 [1.07–1.97]**	**1.60 [1.07–2.40]**	**0.021**
Gender	Male	0.86 [0.73–1.02]	**0.81 [0.68–0.98]**	**0.026**
Occupation	Formal Employment	Ref	Ref	
	Self-employed	**0.69 [0.53–0.89]**	**0.73 [0.55–0.97]**	**0.032**
	Not employed	**0.69 [0.54–0.88]**	**0.69 [0.51–0.93]**	**0.015**
	Student	**0.46 [0.31–0.67]**	**0.6 [0.37–0.98]**	**0.041**
	Part-time employment	–	–	–
	Others	**0.22 [0.13–0.38]**	**0.53 [0.28–1.01]**	**0.054**
Respiration rate (>20)	Yes	1.02 [0.86–1.21]		
Oxygen saturation (<90)	Yes	1.17 [0.96–1.42]	0.91 [0.73–1.15]	0.445
Headache	Yes	0.89 [0.75–1.05]	1.01 [0.83–1.24]	0.901
Fever	Yes	0.97 [0.82–1.15]		
Cough	Yes	**1.21 [0.95–1.54]**	**1.37 [1.05–1.80]**	**0.021**
Chills	Yes	0.86 [0.72–1.02]	0.95 [0.76–1.20]	0.687
Rigors	Yes	1.4 [1.1–1.79]	1.07 [0.78–1.47]	0.684
Sore throat	Yes	**1.35 [1.12–1.64]**	**1.56 [1.23–1.99]**	**<0.001**
Diarrhea	Yes	**1.41 [1.08–1.85]**	1.27 [0.94–1.70]	0.113
Vomiting	Yes	1.10 [0.88–1.37]		
Sore muscles	Yes	**0.76 [0.63–0.92]**	1.12 [0.87–1.45]	0.364
Fatigue/malaise	Yes	0.87 [0.73–1.04]	1.08 [0.87–1.34]	0.475
congestion	Yes	1.14 [0.92–1.41]		
Runny nose	Yes	**1.33 [1.1–1.62]**	**1.51 [1.18–1.94]**	**0.001**
Loss of taste/smell	Yes	1.01 [0.83–1.24]		
Abnormal breathing sounds	Yes	1.06 [0.9–1.26]		
Difficulty in breathing	Yes	1.16 [0.97–1.37]	1.01 [0.82–1.24]	0.933
Haemoptysis	Yes	1.15 [0.82–1.61]		
Ear pain/ discharge	Yes	2.31 [1.36–3.92]	**2.58 [1.43–4.66]**	**0.002**
Skin rash	Yes	1.03 [0.56–1.92]		
Conjuctivitis	Yes	0.97 [0.49–1.9]		
Convulsions	Yes	0.9 [0.52–1.55]		
Phyrangeal exudate	Yes	0.57 [0.41–0.78]	0.71 [0.48–1.04]	0.075
Coma	Yes	0.76 [0.35–1.63]		
HIV	Yes	1.35 [1.09–1.66]	**1.32 [1.04–1.67]**	**0.020**
Neuromuscular disease	Yes	0.57 [0.25–1.29]	0.68 [0.3–1.57]	0.366
TB	Yes	0.85 [0.62–1.17]		
Heart disease	Yes	1.09 [0.8–1.49]		
Malnutrition	Yes	0.86 [0.49–1.52]		
Liver disease	Yes	1.11 [0.54–2.27]		
Diabetes	Yes	1.06 [0.8–1.41]		
Hypertension	Yes	1.06 [0.86–1.3]		
Asthma	Yes	0.69 [0.45–1.07]	0.64 [0.4–1.02]	0.059
Cancer	Yes	0.88 [0.46–1.67]		
Sickle cell	Yes	0.21 [0.03–1.52]	0.29 [0.04–2.08]	0.217

Additionally, we observed that HIV infection was significantly associated with having SARS-CoV-2 infection. Finally, we observed employment status to be associated with SARS-CoV-2 infection with those who were self-employed, unemployed or students having reduced risk compared to those in formal employment.

Older adults (>64 years) are more susceptible to SARS-CoV-2 infections possibly due to waning immune systems and the presence of comorbidities. Specifically, age-related decline and dysregulation of immune function, characterized by immunosenescence and inflammaging, have been shown to increase susceptibility to SARS-CoV-2 infections in older adults [15]. Our findings are consistent with Hu et al., who reported a positive correlation between age and SARS-CoV-2 infection rates in a study of data from 177 countries, with the highest incidence among those aged ≥65 years [16]. Similar results have been reported in diverse settings including South Africa, China and South Korea [17,18]. These observations further corroborates with findings from a systematic review on aging and SARS-CoV-2 susceptibility, showing that aging is linked to an increase in the expression of Angiotensin-Converting Enzyme-2 (ACE-2) [19]. ACE-2 is the receptor for the SARS-CoV-2 spike protein known to facilitate enhanced infection and viral replication in older individuals [19]. Contrary to existing literature [20,21], we found that males were less likely to be infected with SARS-CoV-2 — a finding that would warrant further investigation. Considering these findings, continued prioritization of the elderly in preventive strategies such as vaccination, testing, and treatment for SARS-CoV-2 to mitigate infection risk is necessary.

Sore throat and runny nose can be attributed to the virus's impact on the upper respiratory tract, which leads to inflammation and irritation [22]. Ear pain or discharge may be linked to inflammatory processes affecting the Eustachian tubes and middle ear, consistent with findings in other viral respiratory infections [23]. While severe SARS-CoV-2 infections are mainly a lower respiratory tract infection, the majority of SARS-CoV-2 infections presents as mild upper respiratory tract infection with symptoms such as sore throat and runny nose that could potentially lead to secondary infection of the ear. The above findings are largely similar to those of El- Anwar et al. who conducted a review of ear, nose and throat (ENT) manifestations of COVID-19 and showed that sore throat was the leading manifestation of COVID -19 at 11.3 % while

runny nose was less prevalent at 2.1 %. [24]. These findings highlight the need for broadening COVID-19 symptom awareness since these symptoms, often associated with milder respiratory infections, can also indicate COVID-19. However, because of asymptomatic transmission coupled with the non-specific nature of these symptoms, testing protocols may not yield much in reducing transmission, especially in community settings.

While existing systematic reviews on the intersection of HIV and SARS-CoV-2 infection have not shown HIV to heighten the risk of SARS-CoV-2 infection [25], it has been shown that other factors such as old age and chronic conditions increases the risk of SARS-CoV-2 infection among HIV positive individuals [26]. Despite our findings being inconsistent with existing literature, we hypothesize that the increased likelihood of SARS-CoV-2 infection among patients with HIV can be attributed to their compromised immune systems. HIV weakens the body's ability to fight off infections, making individuals more susceptible to contracting other viruses, including SARS-CoV-2 especially in settings such as Kenya and Mali where personal commitment to adherence with COVID-19 restrictions was less common.

Our observation that those who were self-employed, unemployed or students being less likely to be infected with SARS-CoV-2 aligns with existing literature, which showed that ~ 30 % of workers in the United states worked in jobs where exposure to infection occurred at least once a month [27]. Differences in occupational exposure and social interaction may explain the reduced exposure to such infections among these groups. Specifically, the reduced likelihood of SARS-CoV-2 infection among students could be linked to factors, such as reduced exposure to high-risk environments or the implementation of strict preventive measures in academic settings. During the pandemic, many educational institutions shifted to remote learning or adopted stringent health protocols (e.g., mask mandates, social distancing) that may have limited the spread of the virus among students [28]. This finding highlights the need for public health interventions to account for varying levels of exposure based on employment status, ensuring that preventive strategies are inclusive and adapted to different occupational risks.

Our study has some limitations. First, this study was based on a hospital surveillance and the findings may not reflect the true picture in the larger population. Secondly, our study was not originally powered to assess risk factors for SARS-CoV-2 infection. However, our sample size was sufficiently large to undertake this investigation.

5. Conclusion

Our findings add to the body of literature on the factors associated with SARS-CoV-2 Infection in Africa. In this evaluation of SARS-CoV-2 infection among SRI patients in Kenya and Mali, we found that older age, common upper respiratory symptoms (sore throat and runny nose), and underlying conditions (HIV) were associated with increased infection risk. These findings align with existing WHO guidelines and highlight the need for targeted prevention and management strategies focused on vulnerable groups, including the elderly and those with underlying conditions, while accounting for occupational risk factors.

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Authors contribution

RA, BON, RO and SOS conceived the study. All authors contributed to study design and implementation. RA and BOO, and BON analyzed and interpreted the data. RA drafted the manuscript and all authors critically reviewed the manuscript for intellectual content and approved the final manuscript. All authors read and approved the final manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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