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Epidemiological and clinical characteristics of patients hospitalised with COVID-19 in Kenya: a multicentre cohort study

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ABSTRACT

Objectives To assess outcomes of patients admitted to hospital with COVID-19 and to determine the predictors of mortality.

Setting This study was conducted in six facilities, which included both government and privately run secondary and tertiary level facilities in the central and coastal regions of Kenya.

Participants We enrolled 787 reverse transcriptase-PCR-confirmed SARS-CoV2-infected persons. Patients whose records could not be accessed were excluded.

Primary and secondary outcome measures The primary outcome was COVID-19-related death. We used Cox proportional hazards regressions to determine factors related to in-hospital mortality.

Results Data from patients with 787 COVID-19 were available. The median age was 43 years (IQR 30–53), with 505 (64%) being men. At admission, 455 (58%) were symptomatic with an additional 63 (9%) developing clinical symptoms during hospitalisation. The most common symptoms were cough (337, 43%), loss of taste or smell (279, 35%) and fever (126, 16%). Comorbidities were reported in 340 (43%), with cardiovascular disease, diabetes and HIV documented in 130 (17%), 116 (15%), 53 (7%), respectively. 90 (11%) were admitted to the Intensive Care Unit (ICU) for a mean of 11 days, 52 (7%) were ventilated with a mean of 10 days, 107 (14%) died. The risk of death increased with age (HR 1.57 (95% CI 1.13 to 2.19)) for persons >60 years compared with those <60 years old; having comorbidities (HR 2.34 (1.68 to 3.25)) and among men (HR 1.76 (1.27 to 2.44)) compared with women. Elevated white cell count and aspartate aminotransferase were associated with higher risk of death.

Conclusions The risk of death from COVID-19 is high among older patients, those with comorbidities and among men. Clinical parameters including patient clinical signs, haematology and liver function tests were associated with risk of death and may guide stratification of high-risk patients.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The main strengths of this study are that it was multicentre and included asymptomatic and mild cases, which provides a more comprehensive analysis of the presentation of COVID-19 and reduces bias.
⇒ Asymptomatic participants were admitted during the initial phase of the outbreak as part of the outbreak containment measures and this gave opportunity to document progression of disease.
⇒ Limitations of this study include the absence of laboratory parameters for some of the study patients, pulse oximetry was not routinely recorded during the initial period of the outbreak, and we did not have access to other laboratory markers that have been shown to predict mortality including D-dimers and IL-6.

INTRODUCTION

Ten months since the first case of COVID-19 was reported, more than 45 million cases and 1.2 million people have died from the disease globally. Africa has recorded 1.8 million cases and 42 000 deaths with South Africa reporting the most cases on the continent.[1] Kenya reported its first case on 13 March 2020 and has recorded more than 97 000 cases and 1690 COVID-19 deaths within 10 months with established community transmission in all the 47 counties as documented by the Ministry of Health Emergency Operations Centre.

The epidemiological and clinical characteristics of COVID-19 patients are not fully known. Initial data from China reported a median age of 47 in patients with COVID-19, majority of patients were men with only 5% requiringIntensive care unit care and a 1.4% mortality.[2] On the other hand, limited data from Africa have reported higher mortality for patients younger than 20 years compared with 20–39 year olds,[3] which differs significantly from what is reported elsewhere and underscores the need to understand the disease dynamics in multiple settings.

The COVID-19 disease spectrum ranges from asymptomatic, mild, moderate, severe to critical disease.[4] About 5% of patients have critical disease, which is defined as respiratory failure, shock or multiorgan dysfunction, usually exacerbated by immune hyperactivation such as the cytokine storm.[5] The most common laboratory findings include lymphopenia, elevated aminotransferases, elevated lactate dehydrogenase, elevated C reactive protein (CRP) and elevated D-dimer levels.[6] Common chest radiological findings include ground glass opacities in 83%, mixed ground glass opacities and consolidation in 58%, pleural thickening in 50% and interlobular septal thickening in 48%.[7]

The overall COVID-19 case fatality rate approximates 2.3%.[5] Most fatalities are patients with advanced age or underlying comorbidities. Case fatality also varies by region depending on population characteristics, for example, Italy which has an older population reported a case fatality rate of 7.2% as compared with Korea where the median age is 40 years and the case fatality rate was 0.7%.[8 9] In an analysis of 300 000 patients with confirmed COVID-19 in the USA, mortality was 12 times higher among patients with comorbidities.[10] Comorbidities shown to be risk factors for severe illness include cardiovascular disease, smoking, diabetes mellitus, hypertension, chronic lung disease, chronic kidney disease and obesity.[5] Some laboratory findings have been also associated with poor outcomes. These include lymphopenia, thrombocytopenia, deranged liver function tests, elevated lactate dehydrogenase and raised inflammatory markers.[11]

Whereas detailed reports of clinical features and outcomes of patients hospitalised with COVID-19 are increasing from various parts of the world, data from Africa are scarce. In this paper, we report the epidemiological and clinical features of patients admitted with COVID-19 to Kenyan Hospitals and describe the risk factors for mortality.

METHODS

Study design

This multicentre cohort study recruited patients admitted into six hospitals with laboratory-confirmed diagnosis of SARS-CoV2 between 14 March 2020 and 17 September 2020. The six hospitals (three public hospitals and three private hospitals) had provided dedicated facilities with isolation beds for patients with COVID-19. Two of the public hospitals (Kenyatta National Referral Hospital and Mbagathi Hospital) are located in Nairobi while one public hospital (Coast General Teaching and Referral Hospital) is in Mombasa County at the Coast. The three private hospitals (Nairobi Hospital, Aga Khan University Hospital and Avenue Hospital) are located in Nairobi.

Following the report of the first SARS-CoV-2 case in Kenya on 13 March 2020, the government policy required isolation of all infected persons, including those that were asymptomatic, in health facilities, prior to the adoption of home-based care guidelines on 12 June 2020. Patients with COVID-19 of all ages were recruited into the study. Confirmation of SARS-CoV-2 infection was through real-time PCR testing of nasal and oral-pharyngeal swabs at government-designated COVID-19 testing centres.

Patient and public involvement

The study design did not include patient and public involvement, research questions were informed by the Kenya national COVID-19 subcommittee on case management and front-line healthcare workers. Results from this study will be shared with the national COVID-19 task force and healthcare workers involved in COVID-19 management to inform on stratification and care of patients with COVID-19.

Procedures

We developed a detailed questionnaire that was used to systematically extract information from the medical records of patients with COVID-19 admitted into these study hospitals. Briefly, the questionnaires captured patient information at admission into the hospital, during the hospitalisation until discharge or death. Medical records of the SARS-CoV2-positive patients admitted in the study hospitals were reviewed by a team of trained physicians. They extracted data including patient demographic data, medical history, underlying comorbidities, clinical symptoms, laboratory findings, management and treatment measures and outcome data. Presenting symptoms at admission and during the hospital stay were obtained.

All patients had blood samples drawn for blood count, liver and renal function tests within 24 hours of admission. Patients who had moderate to severe illness got a chest radiograph, CRP and D-dimers in facilities where these investigations were available. Other investigations were ordered as informed by the clinical scenario. Patients with low oxygen saturation were given supplemental oxygen via nasal prongs or masks as appropriate. Patients requiring further respiratory support were admitted to the ICU for either non-invasive or invasive ventilation.

At the beginning of the outbreak in Kenya, patients were given supportive care that included paracetamol for management of fever and antihistamines for any nasal congestion, many patients at the time also received various repurposed drugs, including azithromycin and hydroxychloroquine, in keeping with the little evidence available at the time. As more data became available, dexamethasone became standard of care for severely ill patients on oxygen or requiring mechanical ventilation, and the use of hydroxychloroquine and azithromycin was largely abandoned. Other supportive care given to patients at the time included saline gargles and throat lozenges. Patients with severe illness also received prophylactic anticoagulation with either low-molecular weight or unfractionated heparin depending on availability at the various sites. Access to novel antivirals is still poor in the country. The duration from onset of symptoms to hospital admission,

to requiring ventilation, to ICU admission and to death was recorded.

Data analysis

Categorical variables were presented as counts and percentages, and continuous variables as means with SD for normally distributed data or median with IQRs for data that were not normally distributed. Independent group t tests were used to compare means of continuous variables for normally distributed data, and the non-parametric Mann-Whitney U test for data that were not normally distributed. Comparison between proportions of categorical variables was done using the χ^2 tests. Data from laboratory tests were categorised as normal (within the reference range) or abnormal (outside the reference range).

For survival analysis, the primary outcome of this study was COVID-19-related death, defined as death among patients admitted into the hospital with reverse transcriptase-PCR-confirmed SARS-CoV-2 infection and complications associated with COVID-19. Cox proportional hazards regressions were used to calculate HRs associated with demographics, underlying comorbidities, symptoms, clinical and laboratory characteristics and the CIs set at 95%. All the statistical analyses were carried out using the R statistical software.[12]

RESULTS

Baseline characteristics of the study patients

A total of 787 patients from six health facilities were recruited into the study. The median age was 43 years, with 42% of the patients being below 40 years. Majority of the patients (64%) were men. Nearly two-thirds (67%) of the patients had visited the health facility either after developing symptoms or due to other concerns while the rest had been admitted following the initial government regulations of isolating all laboratory-confirmed positive cases in health facilities. Of the admitted patients, 43% had underlying conditions, with the most common being cardiovascular diseases (17%), diabetes (15%), HIV (7%), cancer (4%), chronic renal disease (3%) and chronic obstructive pulmonary disease (3%) (table 1).

More than half (58%) of the patients were reported to have clinical symptoms during admission, with cough (43%), loss of taste or smell (35%), fever (16%), headaches (13%) and muscle pains (12%) being the most frequent. Seventy-nine (11%) of patients required ICU admission and 59 (7%) were mechanically ventilated. A total of 107 (13.5%) patients died. From the onset of symptoms, the average duration of hospital admission and ICU admission and death were 7 and 6 days, respectively, and the average time to death was 16 days. Table 1 provides a summary of the baseline characteristics of the patients included in the study.

Laboratory findings of the patients

To determine the laboratory findings associated with survival of patients admitted with COVID-19, various blood tests were conducted. The tests included haematology for 448 (57%) of the patients, creatinine (n=433, 55%), D-dimer (n=94, 12%), liver function tests (n=421, 53%), CRP (n=184, 23%) and procalcitonin (n=14, 2%). A majority of patients analysed had neutropenia, lymphopenia, elevated aspartate aminotransferase, elevated lactate dehydrogenase and elevated CRP. The results showed differences in many of these parameters when compared between the survivors and the non-survivors (table 2).

Radiological features

Severely ill patients got chest imaging (n=101). The most common findings included presence of ground glass opacities in 73 (72%), local patchy shadowing in 59 (58%), diffuse patchy shadowing in 61 (60%) and interstitial abnormalities in 29 (29%).

Determinants of time-to-death for patients with COVID-19 admitted in health facilities

To determine the factors associated with death for hospitalised patients with COVID-19, we carried out Cox proportional hazard regression analysis. This was carried out in two stages: univariable analysis of all putative factors, followed by multivariable analysis to identify the significant factors associated with death. Table 3 shows the results of the univariable analysis for all putative factors in the study data set for COVID-19 mortality. Factors with a p value of <0.2 were offered to the multivariable analysis followed by model reduction.

Figure 1 shows the association between the patient-level factors and risk of COVID-19 mortality among the hospitalised patients. Risk of death increased with age with patients over 60 years of age having more than one and half increased risk of death compared with those below 60 years (HR 1.57 (1.13 to 2.19)). Men had a higher risk of COVID-19 mortality compared with women, while those with at least one underlying comorbidity had an increase in risk of death compared with those without. Presence of clinical symptoms was associated with increased risk of COVID-19 mortality.

Several laboratory test results were associated with higher risk of mortality (figure 2). Increased white cell counts, both neutrophilia and neutropenia as well as lymphopenia, low haemoglobin and elevated liver enzymes were associated with increased risk of death from COVID-19.

DISCUSSION

This prospective, multicentre study provides a summary of the epidemiological and clinical features of people with SARS-CoV-2 infection and COVID-19 of varying severity and explores predictors of mortality.

Table 1 Demographics and baseline characteristics of the patients admitted in Kenyan health facilities with COVID-19

Parameter	All patients (n=787)	Survivors (n=680)	Non-survivors (107)	P value
Age in years median (SD)	43 (0–109)	41 (0–109)	55 (0–85)	<0.001
0–20	70 (9%)	66 (10%)	4 (4%)	0.067
21–40	278 (35%)	263 (39%)	15 (14%)	<0.001
41–60	315 (40%)	272 (40%)	43 (40%)	1
60	124 (16%)	79 (12%)	45 (42%)	<0.001
Sex				0.205
Male	505 (64%)	430 (63%)	75 (70%)	
Female	282 (36%)	250 (37%)	32 (30%)	
Healthcare workers	53 (7%)	52 (8%)	1 (1%)	0.006
Patient presented at health facility	524 (67%)	418 (61%)	106 (99%)	<0.001
Underlying comorbidity	340 (43%)	267 (39%)	73 (68%)	<0.001
Cardiovascular disease	130 (17%)	98 (14%)	32 (30%	<0.001
Diabetes	116 (15%)	87 (13%)	29 (27%)	<0.001
HIV	53 (7%)	42 (6%)	11 (10%)	0.172
Cancer	30 (4%)	22 (3%)	8 (7%)	0.063
Chronic renal disease	24 (3%)	14 (2%)	10 (9%)	<0.001
Chronic obstructive pulmonary disease	21 (3%)	13 (2%)	8 (7%)	0.003
Symptoms at admission				
Present during admission	455 (58%)	376 (55%)	79 (74%)	<0.001
Cough	337 (43%)	284 (42%)	53 (50%)	0.160
Loss of taste or smell	279 (35%)	208 (31%)	71 (66%)	<0.001
Fever	126 (16%)	108 (16%)	18 (17%)	0.917
Headache	99 (13%)	94 (14%)	5 (5%)	0.013
Muscle pains	98 (12%)	80 (9%)	18 (17%)	0.188
Fatigue	70 (9%)	66 (10%)	4 (4%)	0.069
Body weakness	35 (4%)	29 (4%)	6 (6%)	0.708
Chest Pains	26 (3%)	23 (3%)	3 (3%)	0.984
Duration of onset of symptoms to:				
i) Hospital admission	7 (0–53)	7 (0–53)	7 (0–38)	0.846
ii) ICU admission	6 (0–38)	7 (0–25)	5 (0–38)	0.282
iii) Death	16 (1–65)		16 (1–65)	<0.001
Hospital course				
ICU admission	90 (11%)	44 (6%)	46 (43%)	<0.001
Ventilation	59 (7%)	13 (2%)	46 (43%)	<0.001

ICU, intensive care unit.

Among COVID-19-positive patients admitted to six COVID-19 hospitals in Kenya between March and August 2020, the median age was 43 years, with 42% below the age of 40 and majority were men (64%). About 43% were found to have underlying chronic conditions, most commonly cardiovascular disease (17%), diabetes mellitus (15%), HIV (7%), malignancies (4%), chronic kidney disease (3%) and chronic airway disease (3%).

The incidence of ICU admission was 90 (11%) with 59 (7%) patients receiving mechanical ventilation. This incidence of severe illness requiring ICU admission is lower than that observed in other cohorts largely from developing countries. Cummings *et al* report on a New York cohort, in which the incidence of ICU admission was 22%.[13]

There are several factors that may account for this lower disease severity. The initial Kenya national containment strategy included admission of all persons testing COVID-19 positive even in the absence of symptoms, this was at a time when over 80% of the patients were asymptomatic.[14] Our patient population was also younger than that reported elsewhere, with a median age of the general

Table 2 Laboratory results of the patients admitted in Kenyan health facilities with COVID-19

Parameter	All patients	Survivors	Non-survivors	P value
Leucocyte count (×10^9 L; normal range 4–10)	n=448	n=352	n=96	
Increased	99 (22%)	55 (16%)	44 (46%)	<0.001
Segmented neutrophils (normal range 45%–75%)		n=354	n=94	
Decreased	289 (65%)	223 (63%)	66 (70%)	<0.001
Increased	41 (11%)	23 (6%)	18 (19%)	0.468
Lymphocyte (normal range 25%–40%)		n=355	n=93	
Decreased	309 (69%)	227 (64%)	82 (88%)	<0.001
Increased	60 (13%)	58 (16%)	2 (2%)	<0.001
Haemoglobin (g/dL normal range: male 14–17, female 12–16)	n=448	n=349	n=99	
Decreased	128 (29%)	76 (22%)	52 (53%)	<0.001
Aminotransferase, alanine (U/L normal range:<35)	n=421	n=316	n=105	
Increased	201 (48%)	132 (42%)	69 (66%)	<0.001
Aminotransferase, aspartate (U/L normal range:<35)	n=421	n=316	n=105	
Increased	214 (51%)	131 (41%)	83 (79%)	<0.001
Lactose dehydrogenase (U/L normal range: 60–100)	n=104	n=66	n=38	
Increased	101 (97%)	64 (97%)	37 (97%)	1
Potassium (mmol/L normal range: 3.5–5)	n=433	n=328	n=105	
Decreased	35 (8%)	28 (9%)	7 (7%)	0.030
Increased	61 (15%)	38 (12%)	23 (22%)	0.178
C reactive protein (mg/L normal range:<5)	n=197	n=137	n=60	
Increased	155 (79%)	96 (70%)	59 (98%)	<0.001

population of 20 years compared with 45 in Italy and 44.9 in Spain, 38.2 in USA and 33 in Brazil, all countries that have seen significantly higher morbidity and mortality. In the New York cohort, they reported a mean age of 62 years and a high prevalence of hypertension (63%) in patients admitted to the critical care units.[13] The prevalence of underlying chronic conditions was lower in our cohort than that reported elsewhere. De Souza and others in an analysis of the epidemic in Brazil report prevalence of 66.5% of cardiovascular disease and 54.5% diabetes in patients with COVID-19.[15] Older age and presence of underlying comorbidities have both been associated with increased risk of severe outcomes in COVID-19.[16 17]

Fifty-eight per cent of our patients were symptomatic at the time of admission with the most common symptoms being cough (58%), loss of taste and smell (35%) and fever (16%). Earlier reports on the epidemic reported fever as the most common symptom followed by cough. In a systematic review and meta-analysis, Hu found the prevalence of fever to be 85.6%, cough at 65.7%, other common symptoms were fatigue and dyspnoea.[18] Loss of smell and taste was fairly prevalent in our population as has been reported elsewhere.[19]

Non-survivors were more likely to be older, have an underlying comorbidity with cardiovascular disease, diabetes mellitus, renal insufficiency and chronic obstructive airway disease more likely to be present in non-survivors. This is in keeping with reports from other cohorts.[20] Many chronic diseases may lead to a state of heightened inflammation and impaired immune responses with an overall lowering of immunity.

On Cox proportional hazard regression analysis, we found significantly increased risk of death with older age (>60), male gender and in patients with comorbidities. Men with COVID-19 have been shown to be at higher risk for worse outcomes and mortality irrespective of age.[21] Malhotra *et al* in a retrospective cohort study in Delhi, looking at 10 314 patients, found that mortality was higher in male patients and with increasing age . Elderly women (>75 years) were noted to have the highest odd of mortality, which was thought to reflect on the poorer healthcare access by this population.[22] Possible explanations for the higher mortality in men include the higher prevalence of high-risk behaviour including smoking and attendant lung injury, higher prevalence of underlying comorbidities and other yet to be fully defined biologic differences.

We found that the presence of a comorbidity was associated with increased mortality, HR 2.34 (CI 1.69 to 3.25). Comorbidities have been associated with higher risk of severe outcomes in many populations. Data from China showed that the HR of severe outcomes including admission to ICU, invasive ventilation and death was 1.79 for patients with at least one comorbidity and 2.59 for patients with two or more comorbidities.[17]

Table 3 Univariable analysis of time to death for COVID-19 patients

Characteristic	HR	95% CI	P value
Age group (*n=787*) (Reference:<20)			
21–40	1.58	0.62 to 4.06	0.3
41–60	3.66	1.49 to 9.03	0.005
>60	5.61	2.24 to 14.0	<0.001
Gender (*n=787*) (reference: female)			
Male	1.62	1.17 to 2.24	0.004
Chronic conditions (*n=787*) (reference: no)			
Yes	2.62	1.92 to 3.58	<0.001
Chronic conditions existing (*n=787*) (reference: no)			
HIV	1.49	0.83 to 2.68	0.2
Chronic renal disease	2.77	1.80 to 4.25	<0.001
Asthma	1.06	0.26 to 4.26	>0.9
Tuberculosis	1.38	0.34 to 5.58	0.6
Diabetes (n=740)	2.02	1.44 to 2.85	<0.001
Ventilation (*n=787*) (reference: no)			
Yes	12.3	9.06 to 16.6	<0.001
Reason hospitalisation (*n=787*) (reference: other reason)			
Visited hospital	106	14.7 to 758	<0.001
Clinical symptoms (*n=787*) (reference: no)			
Yes	1.92	1.38 to 2.67	<0.001
Symptoms existing (*n=787*) (reference: no)	1.13	1.04 to 1.22	0.003
Headache	0.33	0.18 to 0.62	<0.001
Fatigue	0.53	0.31 to 0.90	0.020
Myalgia or arthralgia	0.24	0.03 to 1.71	0.2
Shortness of breath	1.97	1.34 to 2.89	<0.001
Fever	1.92	1.39 to 2.65	<0.001
Cough	1.25	0.93 to 1.67	0.14
Sore throat	1.86	0.92 to 3.79	0.086
Weakness	1.80	1.02 to 3.16	0.042
Chest pains (*n=740*)	0.62	0.25 to 1.50	0.3
Loss of taste or smell	3.43	2.52 to 4.68	<0.001
White blood cells (*n=558*) (reference: normal)			
Decreased	0.57	0.26 to 1.24	0.2
Increased	3.14	2.27 to 4.34	<0.001
Neutrophils (*n=559*) (reference: normal)			
Decreased	3.34	1.88 to 5.95	<0.001
Increased	6.13	3.22 to 11.7	<0.001
Lymphocytes (*n=558*) (reference: normal)			
Decreased	4.17	1.95 to 8.90	<0.001
Increased	0.30	0.06 to 1.45	0.13
Haemoglobin (*n=554*) (reference: normal)			
Decreased	2.81	2.01 to 3.92	<0.001
Increased	0.88	0.40 to 1.94	0.8
Alanine aminotransferase (*n=500*) (reference: normal)			
Increased	2.13	1.54 to 2.95	<0.001

Continued

Table 3 Continued

Characteristic	HR	95% CI	P value
Aspartate aminotransferase (*n=502*) (reference: normal)			
Increased	3.24	2.25 to 4.68	<0.001
Potassium (*n=539*) (reference: normal)			
Decreased	1.15	0.65 to 2.05	0.6
Increased	1.72	1.20 to 2.46	0.003
C reactive protein (*n=263*) (reference: normal)			
Increased	25.9	3.61 to 186	0.001

As countries think of strategies to reduce disease transmission and reduce risk of severe disease and mortality, it is important that these risk factors of older age and presence of comorbidity are taken into account and strategies that identify and shield those at highest risk as defined here are adopted.

We found various laboratory parameters to be associated with increased risk of death, these included leucocytosis, lymphopaenia, transaminitis and elevated CRP. Lymphopaenia has been shown to occur frequently in patients with COVID-19 and to predict severe disease.[23]

Lymphopaenia may result either from suppression of the bone marrow, direct infection and destruction or a cytotoxic-mediated killing of lymphocytes. A functional exhaustion of antiviral lymphocytes has also been reported.[24]

We found elevated alanine and aspartate aminotransferase in 48% and 51% of patients, respectively. Elevations in liver enzymes are common and have been reported to range from 16% to 53% in various studies.[25 26] Boregowda *et al*, in a meta-analysis of studies comparing liver chemistries in mild and severe disease, showed that elevated liver enzymes were associated with severe disease and also predicted mortality.[26] This finding is further strengthened by our study where the presence of elevated aspartate aminotransferase was associated with a HR of death of 2.5 (CI 1.69 to 3.7)

Some of the limitations of our study included the fact that in the initial phase of COVID-19, patients did not routinely get pulse oximetry, hence determination of severity of disease at presentation was not always done. Several other laboratory parameters that have been shown to predict severity of disease such as D-dimer, Ferritin, IL-6 were not routinely measured.

CONCLUSION

In conclusion, this study demonstrates that patients with COVID-19 in Kenya were fairly young with a low rate of

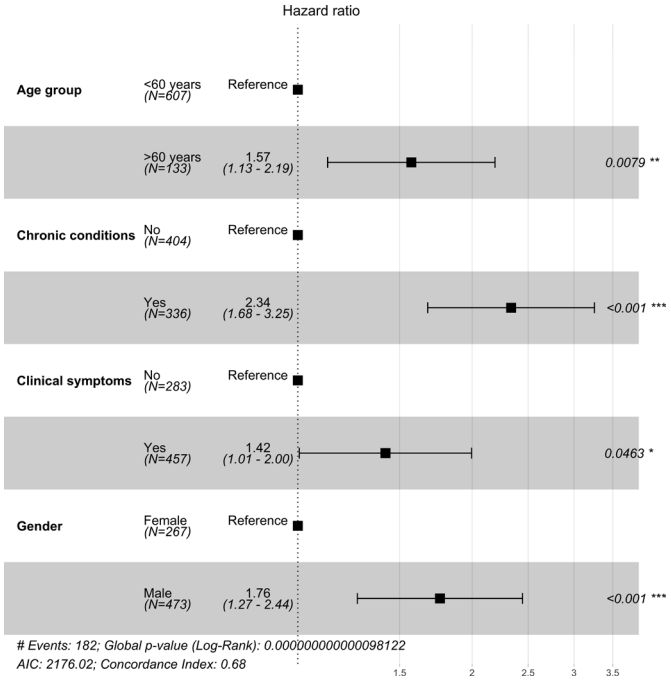

Figure 1 Figure showing the hazard ratios of the statistically significant factors in the multivariable model that are associated with death outcomes among COVID-19 patients admitted in the health facilities.

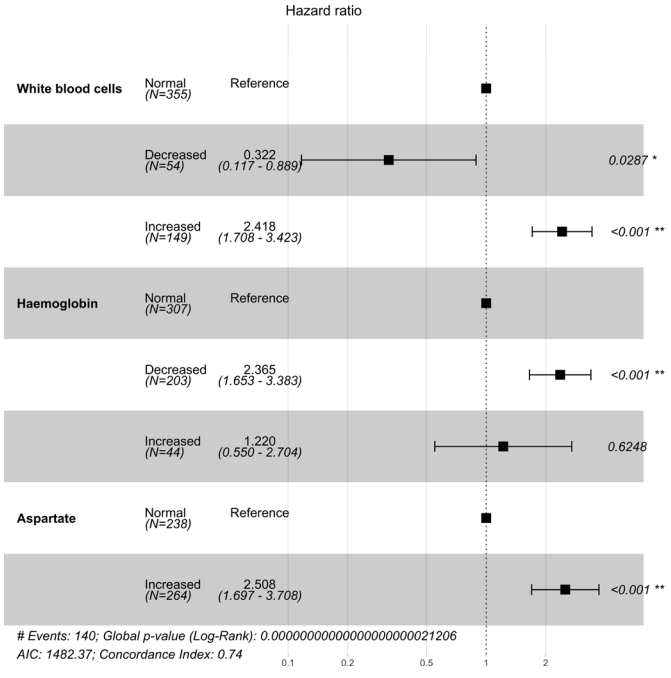

Figure 2 Figure showing the hazard ratios of the laboratory parameters from the multivariate model. An increase in aspartate, decrease in haemoglobin and an increase in the white blood cells increased the hazard ratio by more than 2.

severe disease. Age above 60, male gender, presence of comorbidities, leucocytosis, lymphopaenia and elevated transaminases predicted mortality.

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Data availability statement Data are available upon reasonable request. Individual participant data will be available including data that underlie the results reported in this article after de-identification beginning 9 months and ending 36 months following article publication to investigators with a methodologically sound proposal as those whose proposed use of data has been approved by an independent review committee. Proposals should be directed to loisea@uonbi.ac.ke. After 36 months, the data will be available at our university repository at www.uonbi.ac.ke.

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REFERENCES

1 WHO Coronavirus Disease (COVID-19) Dashboard. WHO Coronavirus Disease (COVID-19) Dashboard [Internet]. Available: https://covid19.who.int/ [Accessed 26 Oct 2020].
2 Guan W-J, Ni Z-Y, Hu Y, *et al*. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med* 2020;382:1708–20.
3 Nachega JB, Ishoso DK, Otokoye JO, *et al*. Clinical characteristics and outcomes of patients hospitalized for COVID-19 in Africa: early insights from the Democratic Republic of the Congo. *Am J Trop Med Hyg* 2020;103:2419–28.
4 Aylward B, Liang W. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). In: *The WHO-China joint mission on coronavirus disease 2019*. , 2020: Vol. 1, 40.
5 Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA* 2020;323:1239–42.
6 Wang D, Hu B, Hu C, *et al*. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA* 2020;323:1061–9.
7 Rodriguez-Morales AJ, Cardona-Ospina JA, Gutiérrez-Ocampo E, *et al*. Clinical, laboratory and imaging features of COVID-19: a systematic review and meta-analysis. *Travel Med Infect Dis* 2020;34:101623.
8 Onder G, Rezza G, Brusaferro S. Case-Fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. *JAMA* 2020;323:1775–6.
9 Korea Centers for Disease Control. *Updates on COVID-19 in Korea*, 2020.
10 Stokes EK, Zambrano LD, Anderson KN, *et al*. Coronavirus Disease 2019 Case Surveillance - United States, January 22-May 30, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:759–65.
11 Wu C, Chen X, Cai Y, *et al*. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. *JAMA Intern Med* 2020;180:934–43.
12 R Core Team. *R: a language and environment for statistical computing*. Vienna, Austria, 2013.
13 Cummings MJ, Baldwin MR, Abrams D, *et al*. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet* 2020;395:1763–70.
14 Ministry of Health Emergency Operations Centre. *COVID-19 outbreak in Kenya daily situation reports*. Nairobi, 2020.
15 de Souza WM, Buss LF, Candido DdaS, *et al*. Epidemiological and clinical characteristics of the COVID-19 epidemic in Brazil. *Nat Hum Behav* 2020;4:856–65.
16 Shahid Z, Kalayanamitra R, McClafferty B, *et al*. COVID-19 and older adults: what we know. *J Am Geriatr Soc* 2020;68:926–9.
17 Guan W-J, Liang W-H, Zhao Y, *et al*. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *Eur Respir J* 2020;55:2000547.
18 Hu Y, Sun J, Dai Z, *et al*. Prevalence and severity of corona virus disease 2019 (COVID-19): a systematic review and meta-analysis. *J Clin Virol* 2020;127:104371.
19 Meng X, Deng Y, Dai Z, *et al*. COVID-19 and anosmia: a review based on up-to-date knowledge. *Am J Otolaryngol* 2020;41:102581.
20 Yang J, Zheng Y, Gou X, *et al*. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *Int J Infect Dis* 2020;94:91–5.
21 Jin J-M, Bai P, He W, *et al*. Gender differences in patients with COVID-19: focus on severity and mortality. *Front Public Health* 2020;8:152.
22 Malhotra V, Basu S, Sharma N, *et al*. Outcomes among 10,314 hospitalized COVID-19 patients at a tertiary care government hospital in Delhi, India. *J Med Virol* 2021;93:4553–8.
23 Zhao Q, Meng M, Kumar R, *et al*. Lymphopenia is associated with severe coronavirus disease 2019 (COVID-19) infections: a systemic review and meta-analysis. *Int J Infect Dis* 2020;96:131–5.
24 Zheng M, Gao Y, Wang G, *et al*. Functional exhaustion of antiviral lymphocytes in COVID-19 patients. *Cell Mol Immunol* 2020;17:533–5.
25 Xie H, Zhao J, Lian N, *et al*. Clinical characteristics of non-ICU hospitalized patients with coronavirus disease 2019 and liver injury: a retrospective study. *Liver Int* 2020;40:1321–6.
26 Boregowda U, Aloysius MM, Perisetti A, *et al*. Serum activity of liver enzymes is associated with higher mortality in COVID-19: a systematic review and meta-analysis. *Front Med* 2020;7:431.