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EPIDEMIOLOGICAL AND CLINICAL CHARACTERISTICS OF COVID-19 PATIENTS IN KENYA

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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 a 6 facilities, that included both government and privately run secondary and tertiary level facilities in the central and costal regions of Kenya.

Participants: We enrolled 787 RT-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 787 COVID-19 patients was available. The median age was 43 years (IQR 30-53), with 505 (64%) being male. At admission, 455 (58%) were symptomatic with an additional 63(9%) developing clinical symptoms during hospitalization. The commonest symptoms were cough (337, 43%), loss of taste or smell (279, 35%), and fever (126, 16%). Co-morbidities 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 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 [hazard ratio (HR) 1.57 (95% CI 1.13 – 2.19)] for persons >60 years compared to those <60 years old; having co-morbidities [HR 2.34 (1.68 – 3.25)]; and among males [HR 1.76 (1.27, 2.44)] compared to females. Elevated white blood 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 co-morbidities, and among males. Clinical parameters including patient clinical signs, haematology and liver-function function tests were associated with risk of death and may guide stratification of high risk patients.

Strengths and Limitations:

- The main strengths of this study is that it was multi-center 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 interleukin 6.

Summary box:
What is already known:
- COVID-19 has been responsible for several million deaths globally.
- Risk factors for severe outcomes described elsewhere have included advanced age, underlying comorbidities and need for ventilation.
- There has been little information on risk factors for severe outcomes from the African context.

What are the new findings:
- In this report, we describe clinical symptoms and findings at presentation and a prevalence of fever lower than previously reported and prevalence of taste and smell abnormalities higher than previous reported.
- We found a lower incidence of severe illness requiring ICU than that reported from western countries.
- We also found risk factors for severe outcomes to be similar to that observed elsewhere including male gender, age above 60, presence of co-morbidities and abnormal laboratory parameters such as leucocytosis, lymphopaenia and transaminitis.

What do the new findings mean:
- The risks for sever outcomes described here can be useful in stratifying patients with COVID-19 for various levels of care in resource limited settings.

Introduction

Ten months since the first case of coronavirus disease (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 13th March 2020 and has recorded more than 97,000 cases and 1,690 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 male with only 5% requiring ICU care and a 1.4% mortality [2]. On the other hand, limited data from Africa have reported higher mortality for <20 years compared to 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 co-morbidities. 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 to 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 United States, mortality was twelve times higher among patients with co-morbidities [10]. Co-morbidities 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 outcome of patients hospitalised with COVID-19 are increasing from various parts of the world, data from Africa is scarce. In this paper we report the epidemiologic and clinical features of patients admitted with COVID-19 to Kenyan Hospitals and describe the risk factors for mortality.

Methods

Study design

This multi-center cohort study recruited patients admitted into six hospitals with laboratory confirmed diagnosis of SARS-CoV2 between 14th March 2020 and 17th September 2020. The six hospitals (3 public hospitals and 3 private hospitals) had provided dedicated facilities with isolation beds for COVID-19 patients. 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, Avenue Hospital) are located in Nairobi.

Following the report of the first SARS-CoV-2 case in Kenya on 13th 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 12th June 2020. COVID-19 patients 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 the government designated COVID-19 testing centres.

The study received ethical approval from the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (approval number P223/03/2020). There was no funding obtained for this study.

Patient and public involvement:

The study design did not include patient and public involvement, research questions were informed by the Kenya national COVID-19 sub-committee on case management and front line health care workers. Results from this study will be shared with the national COVID-19 task force and health care 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 COVID-19 patients admitted into these study hospitals. Briefly, the questionnaires captured patient information at admission into the hospital, during the hospitalization 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 co-morbidities, 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. Patient 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, 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 abandoned. 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 were recorded.

Data analysis

Categorical variables were presented as counts and percentages, and continuous variables as means with standard deviation for normally distributed data, or median with inter-quantile ranges 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 the data not normally distributed. Comparison between proportions of categorical variables was done using the Chi-square tests. The data from laboratory tests was categorized as normal (within the normal range) or abnormal (outside the normal 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 RT-PCR confirmed SARS-CoV-2 infection and complications associated with COVID-19. Cox proportional hazards regressions were used to calculate Hazard ratios (HRs) associated with the demographic, underlying co-morbidities, symptoms, clinical and laboratory characteristics were calculated, and the confidence intervals set at 95%. All the statistical analysis was 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 male. Nearly two thirds (67%) of the patients had visited the health facility 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. 79 (11%) of patients required ICU admission and 59(7%) were mechanically ventilated. 107 (13.5%) of patients died. From the onset of symptoms, the average duration of hospital admission, ICU admission and

death were 7, 6 and 16 days respectively. 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, blood samples were collected, and tests carried out. The tests included haematology for 448 (57%) of the patients, creatinine (n=433, 55%), D-dimer (n=94, 12%), liver function test (n=421, 53%), C- reactive protein (n=184, 23%) and procalcitonin (n=14, 2%). A majority of patients analysed had neutropenia, lymphopenia, elevated aspartate aminotransferase, elevated lactate dehydrogenase and elevated C-reactive protein. The results showed differences in many of these parameters when compared between the survivors and the non-survivors (Table 2).

f*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 COVID-19 patients admitted in health facilities

To determine the factors associated with death outcomes for hospitalized COVID-19 patients, 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 outcomes for patients. Table 3 shows the results of the univariable analysis for all putative factors in the study dataset 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 to those below 60 years [HR 1.57 (1.13 – 2.19)]. Men had a higher

risk of COVID-19 mortality compared to women, while those with at least one underlying co-morbidity had an increase in risk of death compared to 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 blood 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, multi-centre 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.

Among COVID-19 positive patients admitted to six COVID-19 hospitals in Kenya between March - August 2020, the median age was 43 years, with 42% below the age of 40 and majority were male (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 population of 20 years compared to 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 co-morbidities have both been associated with increased risk of severe outcomes in COVID-19 [16,17].

58% 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 co-morbidities. Men with COVID-19 have been shown to be at higher risk for worse outcomes and mortality irrespective of age [21]. Possible explanations for this include the higher prevalence of high-risk behaviour including smoking and attendant lung injury, higher prevalence of underlying co-morbidities 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 1.69-3.25). Co-morbidities have been associated with higher risk of severe outcomes in many populations. Data from China showed that the hazard ratio 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 co-morbidities [17].

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 co-morbidity are taken in to 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 [22].

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 [23].

We found elevated alanine and aspartate aminotransferase in 48% and 51% of patients respectively. Elevations in liver enzymes is common and has been reported to range from 16-53% in various studies [24,25]. 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 predicted mortality [25]. This finding is further strengthened by our our study where the presence of elevated aspartate aminotransferase was associated with a hazard ratio of death of 2.5 (CI 1.69-3.7)

Conclusion

In conclusion, this study demonstrates that patients with COVID-19 in Kenya were fairly young with a low rate of severe disease. Age >60, male gender, presence of co-morbidities, leucocytosis, lymphopaenia and elevated transaminases predicted mortality.

Author contributions:

- Loice Achieng Ombajo - Conceptualisation, methodology, data collection, supervision, data analysis, manuscript writing
- Nyamai Mutono - Methodology, data cleaning, data analysis
- Paul Sudi - Data collection, writing - review and editing
- Mbuvi Mutua - Data collection, writing - review and editing
- Mohammed Sood - Methodology, data collection, writing - review and editing
- Alliy Muhammad Ali Loo - Data collection, writing - review and editing
- Phoebe Juma - Data collection, writing - review and editing
- Jackline Odhiambo - Data collection, writing - review and editing
- Reena Shah - Methodology, data collection, writing - review and editing

- Frederick Wangai - Data collection, writing - review and editing
- Marybeth Maritim - Methodology, writing - review and editing
- Omu Anzala - Methodology, writing - review and editing
- Patrick Amoth - Methodology, writing - review and editing
- Evans Kamuri - Methodology, writing - review and editing
- Waweru Munyu - Data collection, writing - review and editing
- SM Thumbi - Conceptualisation, methodology, data analysis, manuscript writing
- All authors reviewed and authorised the final manuscript

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Tables:

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%)	
Health care 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

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

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

Characteristic	**Hazard Ratio**	**95% CI**	**p-value**
Age group *(n=787)*			
20			
21-40	1.58	0.62, 4.06	0.3
41-60	3.66	1.49, 9.03	0.005
60	5.61	2.24, 14.0	<0.001
Gender *(n=787)*			
Female			
Male	1.62	1.17, 2.24	0.004
Chronic conditions *(n=787)*			
No			
Yes	2.62	1.92, 3.58	<0.001
Ventilation *(n=787)*			
No			
Yes	12.3	9.06, 16.6	<0.001

HIV *(n=787)* No Yes	1.49	0.83, 2.68	0.2
Reason hospitalization *(n=787)* Other Reason Visited Hospital	106	14.7, 758	<0.001
Chronic renal disease *(n=787)* No Yes	2.77	1.80, 4.25	<0.001
Asthma *(n=787)* No Yes	1.06	0.26, 4.26	>0.9
Tuberculosis *(n=787)* No Yes	1.38	0.34, 5.58	0.6
Diabetes *(n=740)* No Yes	2.02	1.44, 2.85	<0.001
Clinical symptoms *(n=787)* No Yes	1.92	1.38, 2.67	<0.001

Number of symptoms	1.13	1.04, 1.22	0.003
Headache *(n=787)*			
No			
Yes	0.33	0.18, 0.62	<0.001
Fatigue *(n=787)*			
No			
Yes	0.53	0.31, 0.90	0.020
Myalgia or arthralgia *(n=787)*			
No			
Yes	0.24	0.03, 1.71	0.2
Shortness of breath *(n=787)*			
No			
Yes	1.97	1.34, 2.89	<0.001
Fever *(n=787)*			
No			
Yes	1.92	1.39, 2.65	<0.001
Cough *(n=787)*			
No			
Yes	1.25	0.93, 1.67	0.14
Sore throat *(n=787)*			
No			

Yes	1.86	0.92, 3.79	0.086
Weakness *(n=787)*			
No			
Yes	1.80	1.02, 3.16	0.042
Chest pains *(n=740)*			
No			
Yes	0.62	0.25, 1.50	0.3
Loss of taste or smell *(n=787)*			
No			
Yes	3.43	2.52, 4.68	<0.001
White blood cells *(n=558)*			
Normal			
Decreased	0.57	0.26, 1.24	0.2
Increased	3.14	2.27, 4.34	<0.001
Neutrophils *(n=559)*			
Normal			
Decreased	3.34	1.88, 5.95	<0.001
Increased	6.13	3.22, 11.7	<0.001
Lymphocytes *(n=558)*			
Normal			
Decreased	4.17	1.95, 8.90	<0.001
Increased	0.30	0.06, 1.45	0.13

Haemoglobin *(n=554)*			
Normal			
Decreased	2.81	2.01, 3.92	<0.001
Increased	0.88	0.40, 1.94	0.8
Alanine aminotransferase *(n=500)*			
Normal			
Increased	2.13	1.54, 2.95	<0.001
Aspartate aminotransferase *(n=502)*			
Normal			
Increased	3.24	2.25, 4.68	<0.001
Potassium *(n=539)*			
Normal			
Decreased	1.15	0.65, 2.05	0.6
Increased	1.72	1.20, 2.46	0.003
C reactive protein *(n=263)*			
Normal			
Increased	25.9	3.61, 186	0.001

Figures:

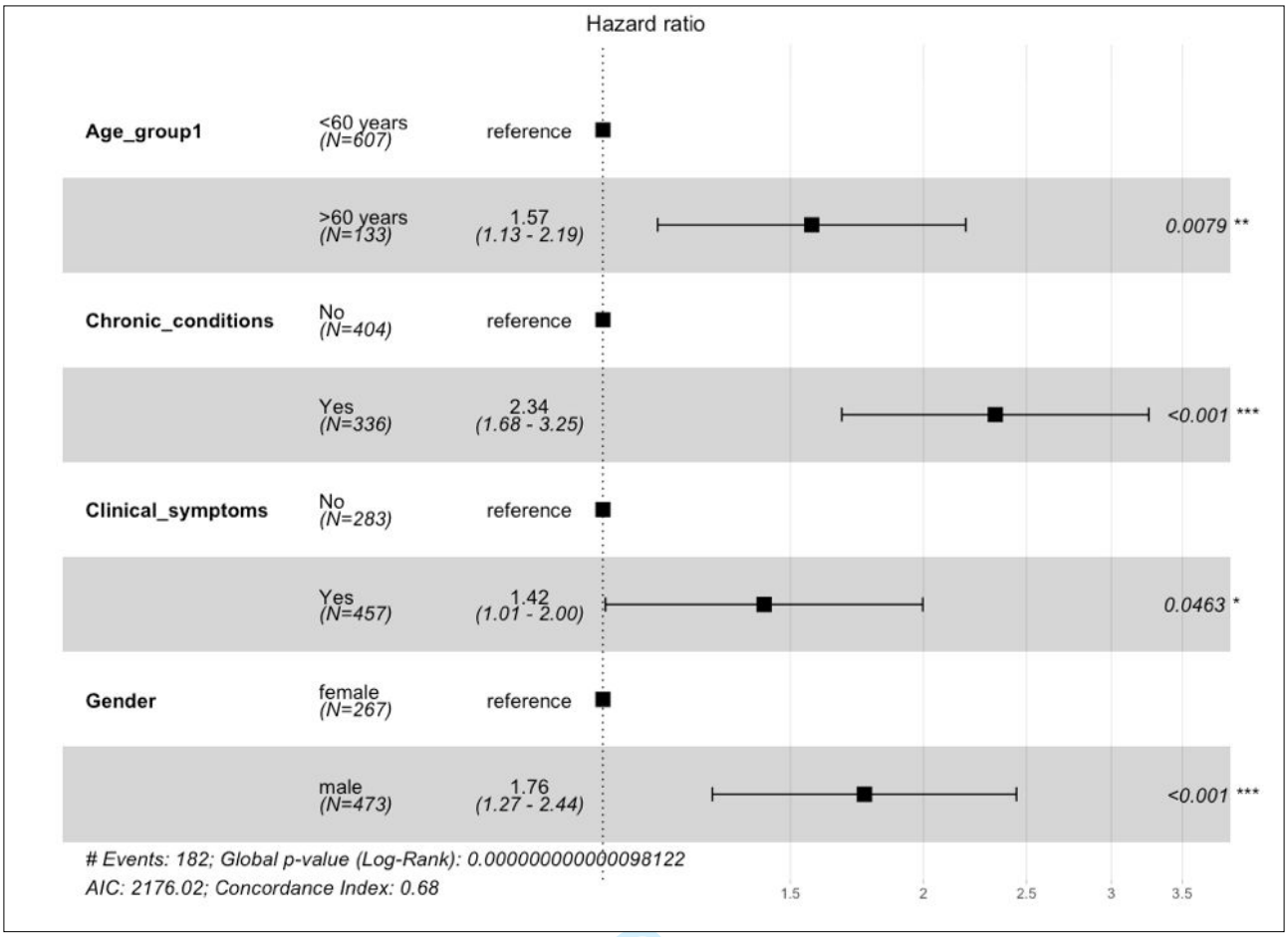

Figure 1: Figure showing the hazard ratios of the statistically significant factors in the multivariable model that are associated with death outcomes among COVID-19 patients admitted in the health facilities

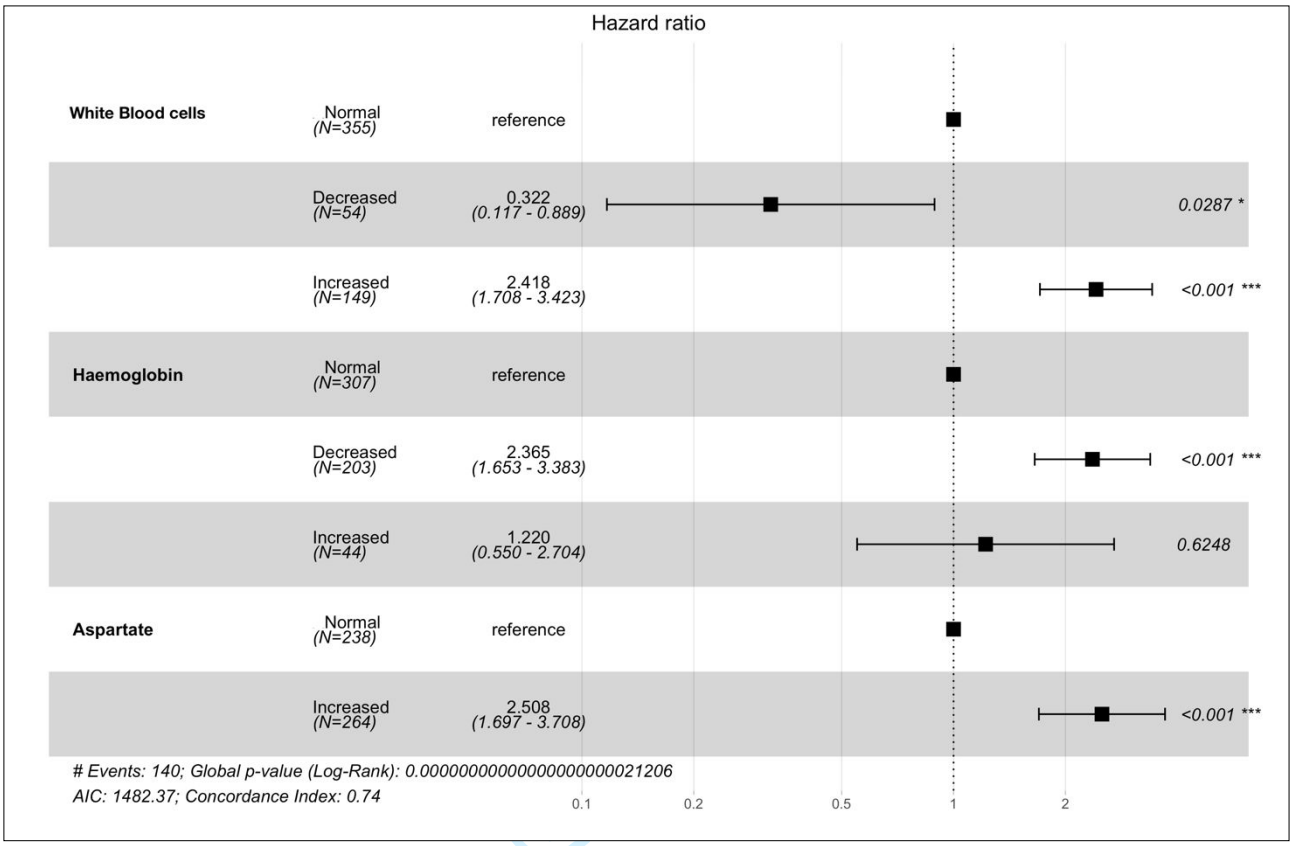

Figure 2: Figure showing the hazard ratios of the laboratory parameters from the multivariate model. An increase in aspartate, decrease in haemoglobin and an increase in the white blood cells increased the hazard ratio by more than 2.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	5
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	Report numbers of outcome events or summary measures over time	7

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	5

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Epidemiological and clinical characteristics of patients hospitalised with COVID-19 in Kenya: a multi-centre 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 6 facilities, that included both government and privately run secondary and tertiary level facilities in the central and coastal regions of Kenya.

Participants: We enrolled 787 RT-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 787 COVID-19 patients was available. The median age was 43 years (IQR 30-53), with 505 (64%) being male. At admission, 455 (58%) were symptomatic with an additional 63(9%) developing clinical symptoms during hospitalization. The commonest symptoms were cough (337, 43%), loss of taste or smell (279, 35%), and fever (126, 16%). Co-morbidities 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 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 [hazard ratio (HR) 1.57 (95% CI 1.13 – 2.19)] for persons >60 years compared to those <60 years old; having co-morbidities [HR 2.34 (1.68 – 3.25)]; and among males [HR 1.76 (1.27, 2.44)] compared to females. Elevated white blood 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 co-morbidities, and among males. 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:

- The main strengths of this study is that it was multi-centre 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 interleukin 6.

Introduction

Ten months since the first case of coronavirus disease (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 13th March 2020 and has recorded more than 97,000 cases and 1,690 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 male with only 5% requiring ICU 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 to 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 multi-organ

dysfunction, usually exacerbated by immune hyper-activation 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 co-morbidities. 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 to 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 United States, mortality was twelve times higher among patients with co-morbidities [10]. Co-morbidities 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 is 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 multi-centre cohort study recruited patients admitted into six hospitals with laboratory confirmed diagnosis of SARS-CoV2 between 14th March 2020 and 17th September 2020. The six hospitals (3 public hospitals and 3 private hospitals) had provided dedicated facilities with isolation beds for COVID-19 patients. 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 13th 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 12th June 2020. COVID-19 patients 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.

The study received ethical approval from the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (approval number P223/03/2020). There was no funding obtained for this study.

Patient and public involvement:

The study design did not include patient and public involvement, research questions were informed by the Kenya national COVID-19 sub-committee on case management and front line health care workers. Results from this study will be shared with the national COVID-19 task force and health care 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 COVID-19 patients admitted into these study hospitals. Briefly, the questionnaires captured patient information at admission into the hospital, during the hospitalization 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 co-morbidities, 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. Patient 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 were recorded.

Data analysis

Categorical variables were presented as counts and percentages, and continuous variables as means with standard deviation for normally distributed data, or median with inter-quartile ranges for data that was 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 was not normally distributed. Comparison between proportions of categorical variables was done using the Chi-square tests. Data from laboratory tests was 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 RT-PCR confirmed SARS-CoV-2 infection and complications associated with COVID-19. Cox proportional hazards regressions were used to calculate Hazard ratios (HRs) associated with demographics, underlying co-morbidities, symptoms, clinical and laboratory characteristics, and the confidence intervals set at 95%. All the statistical analysis was 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 male. 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. 79 (11%) of patients required ICU admission and 59(7%) were mechanically ventilated. 107 (13.5%) of 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%), C- reactive protein (n=184, 23%) and procalcitonin (n=14, 2%). A majority of patients analysed had neutropenia, lymphopenia, elevated aspartate aminotransferase, elevated lactate dehydrogenase and elevated C-reactive protein. 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 COVID-19 patients admitted in health facilities

To determine the factors associated with death for hospitalized COVID-19 patients, 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 dataset 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 to those below 60 years [HR 1.57 (1.13 – 2.19)]. Men had a higher risk of COVID-19 mortality compared to women, while those with at least one underlying co-morbidity had an increase in risk of death compared to 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 blood 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, multi-centre 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.

Among COVID-19 positive patients admitted to six COVID-19 hospitals in Kenya between March - August 2020, the median age was 43 years, with 42% below the age of 40 and majority were male (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 population of 20 years compared to 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 co-morbidities have both been associated with increased risk of severe outcomes in COVID-19 [16,17].

58% 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 co-morbidities. 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 (>75years) were noted to have the highest odd of mortality which was thought to reflect on the poorer health care access by this population [22] . Possible explanations for the higher mortality in males include the higher prevalence of high-risk behaviour including smoking and attendant lung injury, higher prevalence of underlying co-morbidities 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 1.69-3.25). Co-morbidities have been associated with higher risk of severe outcomes in many populations. Data from China showed that the hazard ratio 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 co-morbidities [17].

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 co-morbidity are taken in to 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 is common and has been reported to range from 16-53% 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 our study where the presence of elevated aspartate aminotransferase was associated with a hazard ratio of death of 2.5 (CI 1.69-3.7)

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

Author contributions:

- Loice Achieng Ombajo - Conceptualisation, methodology, data collection, supervision, data analysis, manuscript writing
- Nyamai Mutono - Methodology, data cleaning, data analysis
- Paul Sudi - Data collection, writing - review and editing
- Mbuvi Mutua - Data collection, writing - review and editing
- Mohammed Sood - Methodology, data collection, writing - review and editing
- Alliy Muhammad Ali Loo - Data collection, writing - review and editing
- Phoebe Juma - Data collection, writing - review and editing
- Jackline Odhiambo - Data collection, writing - review and editing
- Reena Shah - Methodology, data collection, writing - review and editing
- Frederick Wangai - Data collection, writing - review and editing
- Marybeth Maritim - Methodology, writing - review and editing
- Omu Anzala - Methodology, writing - review and editing
- Patrick Amoth - Methodology, writing - review and editing
- Evans Kamuri - Methodology, writing - review and editing
- Waweru Munyu - Data collection, writing - review and editing
- SM Thumbi - Conceptualisation, methodology, data analysis, manuscript writing
- All authors reviewed and authorised the final manuscript

Competing interests: There are no competing interests to declare.

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Data sharing statement: 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 a 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

Ethics statement: Ethical approval for this study was received from the Kenyatta National Hospital-University of Nairobi ethics and Research Committee, approval number P223/03/2020.

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Tables:

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%)	
Health care 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

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

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

Characteristic	Hazard Ratio	95% CI	p-value
Age group *(n=787)* (Reference: <20)			
21-40	1.58	0.62, 4.06	0.3
41-60	3.66	1.49, 9.03	0.005
>60	5.61	2.24, 14.0	<0.001
Gender *(n=787)* (Reference: Female)			
Male	1.62	1.17, 2.24	0.004
Chronic conditions *(n=787)* (Reference: No)			
Yes	2.62	1.92, 3.58	<0.001
Chronic conditions existing *(n=787)* (Reference: No)			
HIV	1.49	0.83, 2.68	0.2
Chronic renal disease	2.77	1.80, 4.25	<0.001
Asthma	1.06	0.26, 4.26	>0.9
Tuberculosis	1.38	0.34, 5.58	0.6
Diabetes (n=740)	2.02	1.44, 2.85	<0.001
Ventilation *(n=787)* (Reference: No)			
Yes	12.3	9.06, 16.6	<0.001
Reason hospitalization *(n=787)* (Reference: Other Reason)			
Visited Hospital	106	14.7, 758	<0.001
Clinical symptoms *(n=787)* (Reference: No)			
Yes	1.92	1.38, 2.67	<0.001
Symptoms existing *(n=787)* (Reference: No)	1.13	1.04, 1.22	0.003
Headache	0.33	0.18, 0.62	<0.001
Fatigue	0.53	0.31, 0.90	0.020
Myalgia or arthralgia	0.24	0.03, 1.71	0.2
Shortness of breath	1.97	1.34, 2.89	<0.001
Fever	1.92	1.39, 2.65	<0.001
Cough	1.25	0.93, 1.67	0.14

Sore throat	1.86	0.92, 3.79	0.086
Weakness	1.80	1.02, 3.16	0.042
Chest pains *(n=740)*	0.62	0.25, 1.50	0.3
Loss of taste or smell	3.43	2.52, 4.68	<0.001
White blood cells *(n=558)* (Reference: Normal)			
Decreased	0.57	0.26, 1.24	0.2
Increased	3.14	2.27, 4.34	<0.001
Neutrophils *(n=559)* (Reference: Normal)			
Decreased	3.34	1.88, 5.95	<0.001
Increased	6.13	3.22, 11.7	<0.001
Lymphocytes *(n=558)* (Reference: Normal)			
Decreased	4.17	1.95, 8.90	<0.001
Increased	0.30	0.06, 1.45	0.13
Haemoglobin *(n=554)* (Reference: Normal)			
Decreased	2.81	2.01, 3.92	<0.001
Increased	0.88	0.40, 1.94	0.8
Alanine aminotransferase *(n=500)* (Reference: Normal)			
Increased	2.13	1.54, 2.95	<0.001
Aspartate aminotransferase *(n=502)* (Reference: Normal)			
Increased	3.24	2.25, 4.68	<0.001
Potassium *(n=539)* (Reference: Normal)			
Decreased	1.15	0.65, 2.05	0.6
Increased	1.72	1.20, 2.46	0.003
C reactive protein *(n=263)* (Reference: Normal)			
Increased	25.9	3.61, 186	0.001

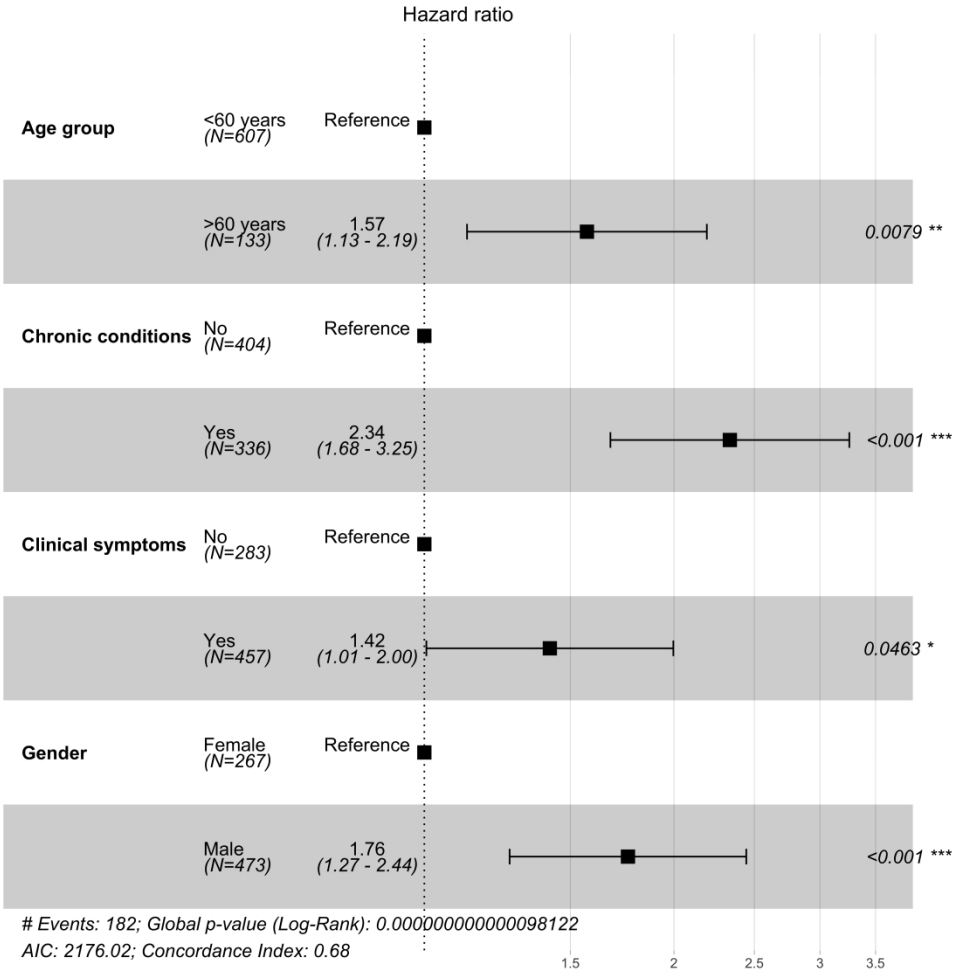

Figure 1: Figure showing the hazard ratios of the statistically significant factors in the multivariable model that are associated with death outcomes among COVID-19 patients admitted in the health facilities

1905x1905mm (72 x 72 DPI)

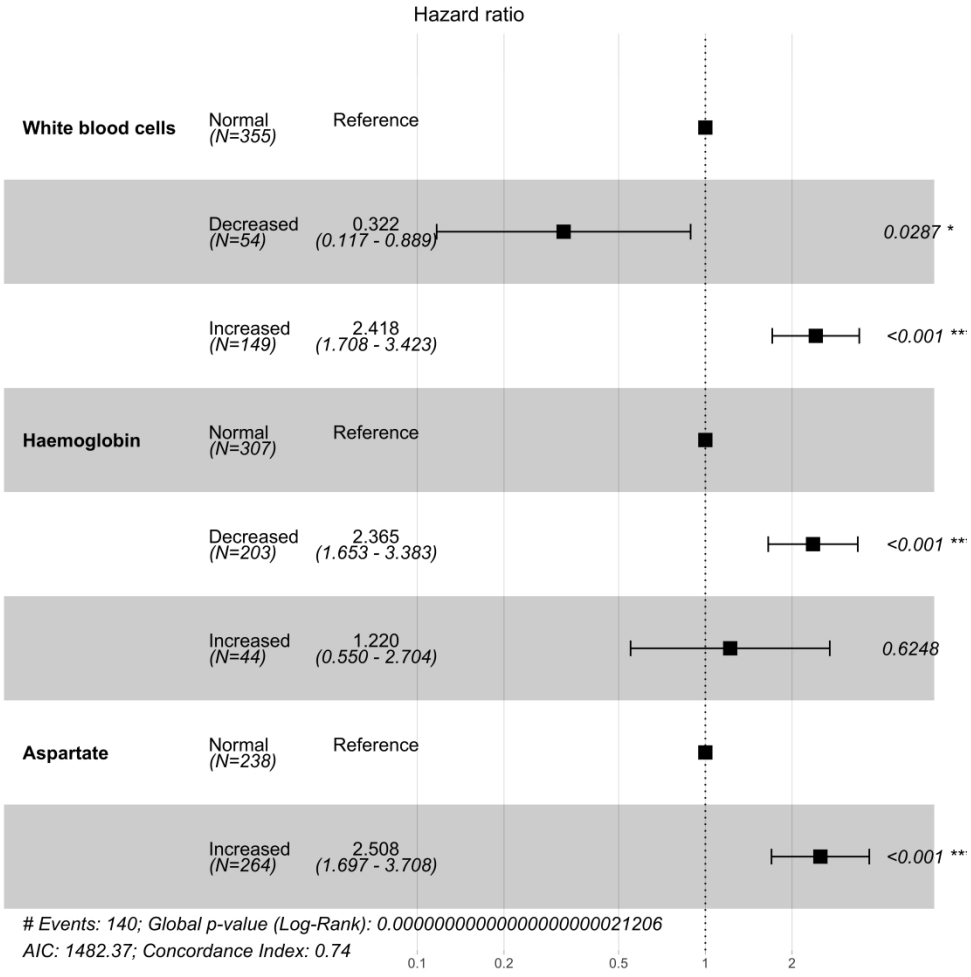

Figure 2: Figure showing the hazard ratios of the laboratory parameters from the multivariate model. An increase in aspartate, decrease in haemoglobin and an increase in the white blood cells increased the hazard ratio by more than 2.

1905x1905mm (72 x 72 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	5
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	Report numbers of outcome events or summary measures over time	7

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	5

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.