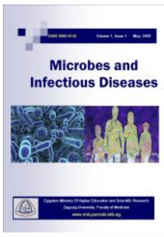
Microbes and Infectious Diseases 2025; 6(2): 444-454



Microbes and Infectious Diseases

Journal homepage: https://mid.journals.ekb.eg/

Original article

COVID-19 infection in a resource-limited setting: Predictors of severity and mortality

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ARTICLE INFO

Article history:
Received 1 November 2024
Received in revised form 16 December 2024
Accepted 29 December 2024

Keywords:
COVID-19 infection
Predictor
severity
mortality
D-dimer

ABSTRACT

Background: Following the declaration of COVID-19 infection as a pandemic by the World Health Organization (WHO), researchers have been working to identify diagnostic and prognostic markers while considering the accuracy and cost-effectiveness of the selected method. This study aimed to identify common COVID-19 infection clinical severity and outcome predictors in a resource-constrained setting. **Method:** This analytical cross-sectional study involved 91 COVID-19 infection patients diagnosed with real-time polymerase chain reaction (RT–PCR) for SARS-CoV-2. The prognostic usefulness of several COVID-19 infection predictors was assessed using multiple logistic regression analysis and the receiver operating characteristic (ROC) curve. A P value< 0.05 is considered significant. **Results:** The mean age of the participants was 65.37±12.13 years, with males being predominant 51(56%). Furthermore, age, body mass index, haemoglobin, total white blood cell count, neutrophil count, lymphocyte count, neutrophil-to-lymphocyte ratio, serum creatinine, D-dimer, C-reactive protein, random blood sugar, spontaneous oxygen saturation and respiratory rate were found to be strongly correlated with the severity and mortality of COVID-19 infection (P values< 0.05). Among the different biomarkers studied, the most reliable predictors of COVID-19 infection severity and mortality were the neutrophil-lymphocyte ratio (for severity; aOR = 8.060, AUC = 0.81 and for mortality; aOR = 4.139, AUC = 0.85) and D-dimer level (for severity; aOR = 4.695, AUC = 0.77, and for mortality; aOR = 3.508, AUC = 0.82). **Conclusions:** This study identified several independent, inexpensive, simple, and important biomarkers of COVID-19 infection that can be used for patient stratification and resource allocation, especially in resource-limited settings.

Introduction

As of August 9, 2023, the global COVID-19 infection pandemic has impacted over 760 million people and killed more than 6.9 million [1]. A considerable number of individuals infected with SARS-CoV-2 do not exhibit any symptoms [2, 3]. Furthermore, when COVID-19 patients exhibit symptoms, the majority only have mild (40%) or moderate (40%) illness. 15% have severe diseases that require oxygen support; and 5% have critical diseases with complications such respiratory failure, ARDS, sepsis and septic shock, thromboembolism, and/or multiorgan failure, including acute kidney injury and cardiac injury [4].

DOI: 10.21608/MID.2024.332889.2325

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Several prognostic indicators have been suggested to evaluate clinical severity and prognosis of COVID-19 infection, assisting healthcare providers and facilities in appropriately classifying and managing COVID-19 patients. Low levels of lymphocytes, eosinophils, and platelets in patients with COVID-19 may be a sign of underlying endothelial and inflammatory dysfunction [5, 6]. Furthermore, the available data suggests that elevated neutrophil-to-lymphocyte ratio (NLR), several cytokines, C-reactive protein, blood urea nitrogen, D-dimer and serum creatinine in COVID-19 patients could be helpful in classifying and/or identifying hospitalized patients, and they are linked to in-hospital mortality [6-8]. Additionally, patients diagnosed with COVID-19 infection exhibit worse prognosis when comorbidities such as heart disease, diabetes mellitus, hypertension and older age are present [9, 10].

Based on location, financial status and ethnic background, the burden and distribution of COVID-19 differ among settings [10]. In a country with limited income, such as Sudan, this study aimed to determine common physical and laboratory predictors of the severity and outcome of COVID-19 infections.

Materials and Methods

Study design, duration and setting

This was a hospital-based, prospective, cross-sectional, analytical study that was carried out between February and April 2021. The data were collected from the isolation centers of Royal Care Hospital and Al-Baraha Medical City in the state of Khartoum.

Study population and eligibility criteria

The study only included admitted patients over 18 years old who proved positive for COVID-19 infection (as assessed by positive RT-PCR of nasal or throat specimens). Patients with suspected COVID-19 (negative test results), autoimmune disease, hematological malignancies, recent chemotherapy, diseases that impair immune function or long-term steroid therapy (more than 3 months) were excluded.

Sample size and sampling technique

The study comprised 91 patients with confirmed COVID-19 infection who were recruited via convenience nonprobability sampling and admitted to isolation hospitals during the study period.

Operational definitions

The WHO COVID-19 disease severity categorization [11] classifies COVID-19 symptoms as follows:

- Critical COVID-19; which can be defined using the following criteria: acute respiratory distress syndrome (ARDS), sepsis, septic shock, or other illnesses that typically require life-sustaining interventions such as positive ventilation or vasopressor therapy.
- Severe COVID-19, defined as oxygen saturation below ninety percent in room air. Adults have a breathing rate that exceeds 30 breaths per minute. Signs of severe respiratory distress include auxiliary muscle use and difficulty completing words.
- Non-severe COVID-19 is characterized as not meeting any severe or critical criterion.

The outcome was classified as follows:

- Survivors/discharged patients
- No survivors/died patients

Data collection and procedure

A structured questionnaire collecting demographic and medical history data was completed. Physical measurements (weight, height, BMI, and initial oxygen saturation) were calculated using standard measures. A 10 mL blood sample was collected for laboratory testing using standard aseptic techniques. The complete blood count (CBC) sample was obtained in an EDTA container and tested with an automatic hematology analyzer, the Mucay BC-3000. Chemical test samples (including RFTs, CRP, and D-dimer) were collected in a lithium heparin container and analyzed on a COBAS 6000 chemistry analyzer. The coagulation profile sample was taken in a sodium citrate container and tested on an STA Compact Max analyzer.

Quality control

Sample analysis was carried out with caution. Every day, the analyzer was calibrated to meet industrial standards. As an external quality control measure, ten percent of the samples were reanalyzed in the reference laboratory.

Data analysis:

The data were gathered and tabulated for analysis using the Statistical Package for the Social Sciences version 25.0 (SPSS, Inc., Chicago, IL, USA). Continuous data is provided as means and standard deviations (SDs), whereas categorical data are presented as numbers and percentages. The Shapiro-Wilk test was employed to assess the normality of data. For normally distributed data, relationships between factors were examined using t tests and ANOVA. We employed Pearson's chi-square test, Fisher's exact test, Mann-Whitney test, and Kruskal-Wallis test to analyze abnormally distributed data. Moreover, Correlation (Spearman) analysis was utilized to determine connections between quantitative variables. A multivariate logistic regression analysis was used to identify determinants of COVID-19 severity and outcome. A receiver operating characteristic (ROC) curve was used to estimate the prognostic value of various variables; an area under the curve (AUC) larger than 0.7 was regarded appropriate for analysis. A P value < 0.05 is deemed significant.

Ethical consideration

All procedures involving human participants in this study were carried out in compliance with the institutional and/or national research committee's ethical standards, as well as the 1964 Declaration of Helsinki and subsequent revisions, or comparable ethical standards. The study was approved by the Faculty of Medicine's Institutional Ethical Committee at National Ribat University, as well as the Khartoum Ministry of Health. After explaining the research technique and studying objectives in clear, simple language, each participant signed a written informed consent.

Results

Sociodemographic characteristics of the study participants

The study included 91 patients, the mean age was 65.3±12.13 years, and the gender distribution was 56% male and 44% female. The patients had an average BMI of 26.7±4.8 kg/m2, ranging from 17-40. The most prevalent comorbidities were hypertension (HTN) 45 (49.4%), followed by diabetes mellitus 40 (43.9%) and ischemic heart disease (IHD) 18 (19.7%), while many patients had several comorbidities. The majority of patients (71.4%) had severe or critical disease, and 52 (57.1%) died in the hospital. **Table 1.**

Variables related to the clinical severity of COVID-19

The majority of patients 65 (71.5%) were diagnosed with a severe or critical condition. Only age and comorbidities (hypertension) were found to be strongly linked to the severity of COVID-19. **Table 2**.

Furthermore, D-dimer, total white blood cells, hemoglobin, neutrophils, lymphocytes, the neutrophil-lymphocyte ratio, random blood sugar, serum creatinine, C-reactive protein, spontaneous oxygen saturation, respiratory rate, and body mass index were substantially related to the severity of infection. **Table 3.**

Spearman correlation analysis revealed that age, body mass index, hemoglobin, total white blood cell count, random blood sugar, neutrophil count, serum creatinine, lymphocyte count, C-reactive protein, neutrophil–to-lymphocyte ratio, serum creatinine, spontaneous oxygen saturation and respiratory rate were substantially correlated to the severity of infection. **Table 4.**

Multivariate regression study revealed that neutrophil-to-lymphocyte ratio, age and D-dimer were the only significant determinants of infection severity. **Table 5.** This is supported by the receiver operating characteristic (ROC) curves. **Figure 1; Table 6.**

Variables related to the outcome of COVID-19

Fifty-two (57.1%) of the patients died during their hospital stay. The outcome was significantly related to age and comorbidities (hypertension and ischemic heart disease). **Table 2**. Furthermore, the total white blood cell count, platelet count, D-dimer level, neutrophil count, serum creatinine level, lymphocyte count, C-reactive protein level, neutrophil–lymphocyte ratio, spontaneous oxygen saturation, and respiratory rate were strongly related with the outcome of patients with infection. **Table 3.**

The Spearman correlation analysis revealed that total white blood cell count, age, D-dimer, neutrophil count, serum creatinine, lymphocyte count, C-reactive protein, neutrophil-to-lymphocyte ratio, spontaneous oxygen saturation, and respiratory rate were significantly correlated to the outcome of patients with infection. **Table 4.**

Multivariate regression analysis revealed that only age, body mass index, neutrophil-lymphocyte ratio, and D-dimer were significant determinants of infection outcome. **Table 5**. This is supported by the result of receiver operating characteristic (ROC) curves. **Figure 2; Table 6**.

Table 1: Characteristics, severity and outcomes of the study participants

Age(years)	**Mean ± SD**	**Range**
	65.37±12.13	19-85
Sex		
	Number	**Percentage**
Males	51	56
Females	40	44
Co morbidities		
None	20	21.9
HTN	45	49.4
DM	40	43.9
IHD	18	19.7
CKD	8	8.7
Active neoplasm	4	4.3
Thyroid dysfunctions	4	4.3
Others	23	25.2
Severity		
Non-severe	26	28.6
Severe	36	39.6
Critical	29	31.9
Outcome		
Discharge home	39	42.9
Death	52	57.1

DM Diabetes mellitus, HTN Hypertension, IHD Ischemic heart disease, CKD chronic kidney disease, SD standard deviation

Table 2: Demographic factors associated with the severity and outcome of COVID-19

	Total 91(100%)	**Discharged** 39(42.9%)	**Dead** 52(57.1%)	**P value**	**Non severe** 26(28.5%)	**Severe** 36(39.6%)	**Critical** 29(31.9%)	**P value**
Sex								
Males	51 (56%)	20 (48.7%)	31 (59.6%)	0.523	14(27.5%)	18(35.3%)	19(37.3)	0.440
Females	40 (44%)	19 (51.3%)	21 (40.4%)		12(30%)	18(45%)	10(25%)	
Age(years)								
Mean ± SD	65.37±12.13	58.92±13.08	70.21±8.75	**0 .001*a**	58.46±11.18	68.5±11.89	67.69±11.05	**0.001*c**
Co morbidities								
None	20 (12.3%)	12 (22.6%)	8(7.3%)	0.068	9(26.5%)	4(5.7%)	7(12.1%)	0.083
HTN	45 (27.8%)	14(26.4%)	31(28.4%)	**0.021*b**	8(23.5%)	23(32.9%)	14(24.1%)	**.036*d**
DM	40 (24.7%)	14 (26.4%)	26(23.9%)	0.130	10(29.4%)	18(25.7%)	12(20.7%)	0.628
IHD	18 (11.1%)	3 (5.7%)	15(13.8%)	0.**01*b**	2(5.9%)	8(11.4%)	8(13.8%)	0.162
CKD	8 (4.9%)	1 (1.9%)	7(6.4%)	0.070	--------	4(5.7%)	4(6.9%)	-----
Active neoplasm	4 (2.5%)	2(3.8%)	2(1.8%)	0.576	1(2.9%)	2(2.9%)	1(1.7%)	0.907
Thyroid dysfunctions	4 (2.5%)	1 (1.9%)	3(2.8%)	0.424	1(2.9%)	2(2.9%)	1(1.7%)	0.907
Others	23 (14.2%)	6 (11.3%)	17(15.6%)	**0.049*b**	3(8.8%)	9(12.9%)	11(19.0%)	0.080

DM Diabetes mellitus, HTN Hypertension, IHD Ischemic heart disease, CKD Chronic kidney disease, SD Standard deviation
**a: Student's t-test. *b: Fisher's exact test. *C: ANOVA test. *d: Pearson's chi-square test.*

Table 3: Initial admission factors associated with the severity and outcome of COVID-19

Parameter	All patients		Severity			P value	outcome		P value
	Mean ±SD	**Range**	**Non-severe**	**Severe**	**Critical**		**Death**	**Discharge home**	
Number (n) (%)	**91(100%)**		**26(28.5%)**	**36(39.6%)**	**29(31.9 %)**	-	**52(57.1%)**	**39(42.9%)**	-
Initial admission investigations									
HGB (g/dl)	12.4±1.97	6.9-15.9	13.3±1.7	12.2±1.7	11.9±2.0	**0.013***	12.1±1.98	12.9±1.8	0.069
PLT (x10³/ µl)	244.5±102	45-502	250.7±99.2	257.4±105	223±102.4	0.234	228.5±103.4	265.9±10	**0.008**
TWBC's (x10³/ µl)	12.6±19.9	2.8-192	7.4±3.2	15.3±30.64	13.8±7.9	**0.001***	12.1±6.5	13.5±4.8	**0.002***
Neutrophil (x10³/ µl)	9.8±5.3	2.5-31.0	7.2±3.1	9.3±4.3	12.6±6.8	**0.003***	11.00±5.5	8.30±4.7	**0.006***
Lymphocyte (x10³/ µl)	3.1±17.5	20-168	1.7±1.09	5.6±2.7	1.2±1.8	**0.001***	1.1±1.5	5.8±2.7	**0.001***
NLR	12.2±11.3	0.09 -59.0	5.8±6.0	12.9±10.5	16.9±13.2	**<0.001***	15.7±12.3	7.63±7.6	< **0.001***
Creatinine (mg/dl)	1.6±1.4	0.3-10.3	1.04±1.3	1.8±2.4	1.8±1.8	**0.01**	2.1±2.29	1.0±1.0	< **0.001***
D-dimer (mg/l)	3.0 ±3.3	0.09-16.8	0.7±0.8	3.6±3.4	4.2±3.7	< **0.001***	1.4±2.1	4.2±3.5	< **0.001***
CRP (mg/l)	161.±122.9	1-522	83.4±101.6	173.6±102.7	216.4±131.1	< **0.001***	195.1±123.1	116.85±110.2	**0.002***
Initial RBS (mg/dl)	185.5±99.4	86-472	131.7±54.0	218.6±107	192.5±102.5	**0.001***	201.1± 106.4	166.42±86.8	0.103
Initial admission measures									
SPO2 (%)	86.7±11.1	40-100	95.5±2.9	86.5±8.17	79.2±13.2	< **0.001***	81.8±12.0	93.4±4.4	< **0.001***
RR (bpm)	27.45±8.4	11-54	20.9±8.6	28.8±5.7	31.4±7.9	< **0.001***	31.1±6.7	22.4±8.1	< **0.001***
BMI	26.7 ± 4.8	17-40	24.6±4.2	26.9±4.4	28.3±5.34	**0.018***	27.6±4.6	25.6±5.0	0.053

SD Standard deviation, TWBCs Total white blood cells, HGB Hemoglobin, PLT Platelets, NLR Neutrophil lymphocyte ratio, CRP C-reactive protein, RBS Random blood sugar, SPO2 Spontaneous oxygen saturation, RR Respiratory rate, BMI Body mass index
** Significance of difference in t-test and ANOVA for normally distributed data. Mann-Whitney test and Kruskal-Wallis test for data following non-normal distribution.*

Table 4: Factors significantly correlated with the severity and final outcome of COVID-19 infection

Parameter	Severity		outcome	
	ρ coefficient	**P value**	**ρ coefficient**	**P value**
Age (**years**)	0.402	< **0.001***	0.469	< **0.001***
BMI	0.278	**0.008***	0.204	0.052
Hb (**g/dl**)	-0.307	**0.003***	-0.192	0.069
TWBs(**x10³/ µl**)	0.381	< **0.001***	0.324	**0.002***
Neutrophils count(**x10³/ µl**)	0.304	**0.003***	0.292	**0.005***
Lymphocytes count (**x10³/ µl**)	-0.375	< **0.001***	-0.349	**0.001***
NLR	0.479	< **0.001***	0.457	< **0.001***
S. Creatinine (**mg/dl**)	0.307	**0.003***	0.383	< **0.001***
D-dimer (**mg/l**)	0.553	< **0.001***	0.551	< **0.001***
CRP(**mg/l**)	0.451	< **0.001***	0.332	< **0.001***
Initial RBCs (**mg/dl**)	0.376	< **0.001***	0.172	0.104
SPO2 (**%**)	-0.688	< **0.001***	-0.610	< **0.001***
RR(**Bpm**)	0.521	< **0.001***	0.550	< **0.001***

BMI Body mass index, HGB Hemoglobin, TWBCs Total white blood cells, NLR Neutrophil lymphocyte ratio, S Serum, CRP C-reactive protein, RBS Random blood sugar, SPO2 Spontaneous oxygen saturation, RR Respiratory rate
**Spearman correlation*

Table 5: Significant predictors of the severity and outcome of COVID-19

	Predictor	Coefficients β	Adjusted Odd Ratio	95% CI		P value
				Lower	upper	
Severity	**Age(years)** **<67** **≥ 67**	1.382	 -- 3.985	1.139	13.942	**0.031**
	NLR <**9.3** **≥9.3**	2.087	 -- 8.060	1.980	32.812	**0.004**
	D-dimer(mg/L) < **1.59** ≥ **1.59**	1.420	 -- 4.139	1.095	15.644	**0.036**
Outcome	**Age(years)** **<67** **≥ 67**	1.447	 -- 4.249	1.426	12.662	**0.009**
	BMI < **27** ≥ **27**	1.359	 -- 3.893	1.230	12.323	**0.021**
	NLR <**9.3** **≥9.3**	1.547	 -- 4.695	1.438	15.326	**0.010**
	D-dimer(mg/L) < **1.59** ≥ **1.59**	1.255	 -- 3.508	1.147	10.731	**0.028**

NLR Neutrophil lymphocyte ratio, BMI Body mass index, CI Confidence intervals.
Continuous variables were dichotomized at the median value.

Table 6: Accuracy of the NLR and D-dimer level in predicting COVID-19 severity and the outcome

predictor	Optimum cut-off	sensitivity	specificity	PPV	NPV	AUC	P value
NLR(Severity)	4.5	83.1%	53.8%	81.8%	56%	**0.81***	< 0.001
NLR(outcome)	6.5	84.6%	71.8%	80%	77.8%	**0.77***	<0.000
D-dimer(severity)	0.5 mg/l	89.2%	57.7%	84.1%	68.2%	**0.85***	< 0.001
D-dimer(outcome)	1.5 mg/l	71.2%	76.9%	80.4%	66.7%	**0.82***	<0 .001

NLR Neutrophil lymphocyte ratio, PPV Positive predictive value, NPV Negative predictive value, AUC Area under the curve
**Significant*

Figure1: ROC curves of the NLR and D-dimer level for predicting COVID-19 severity.

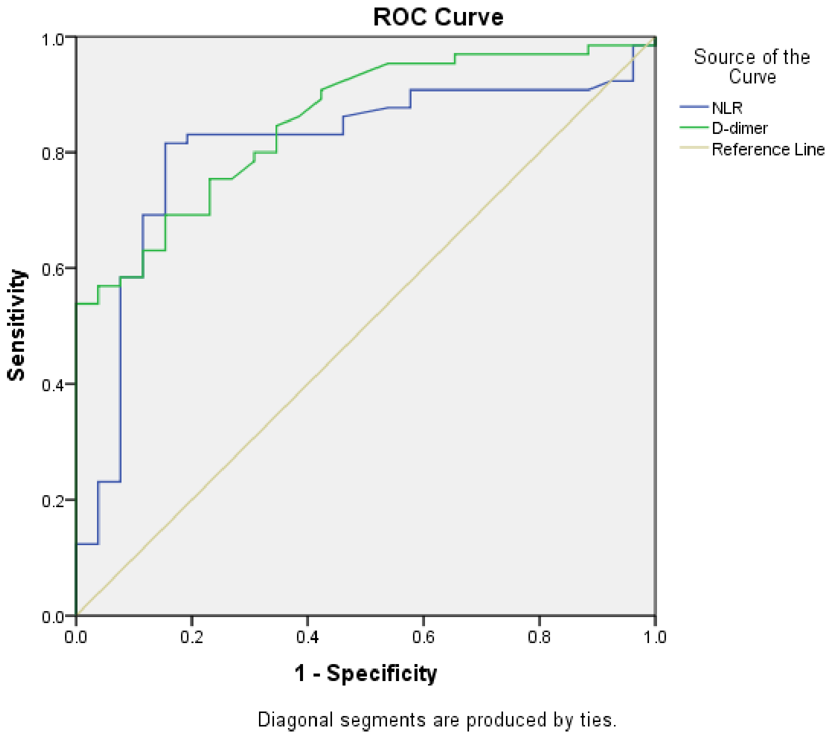
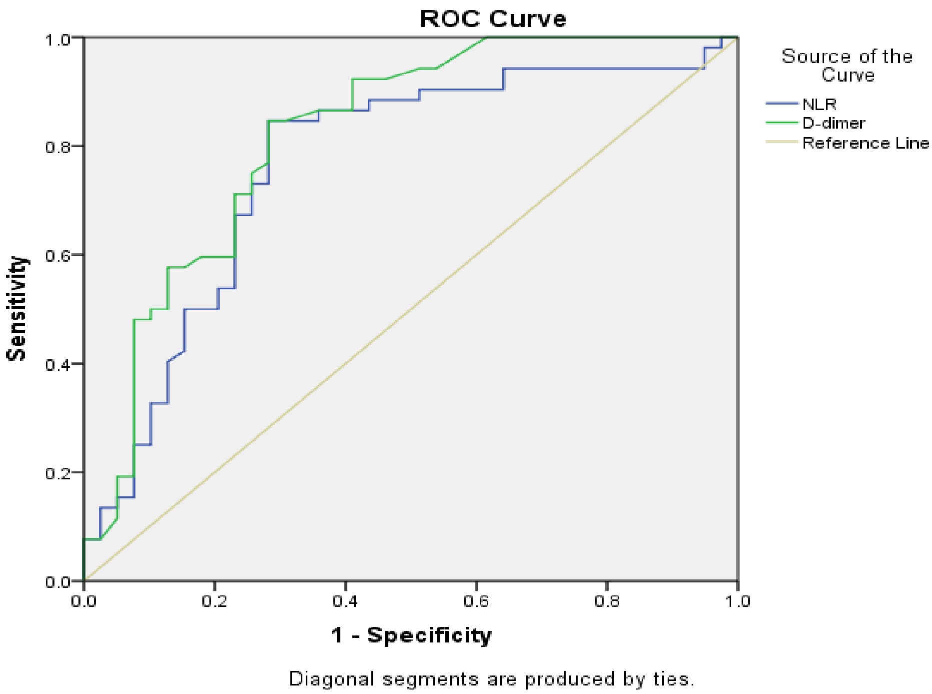


Figure 2: ROC curve of the ability of the NLR and D-dimer level to predict the outcome of patients with COVID-19 infection.



Discussion

Since the COVID-19 outbreak in 2019, the globe has been racing to develop vaccines and therapies and to monitor biological and laboratory changes to serve as markers for predicting the disease course. In this study, we examined a sample of 91 patients who had been found to have COVID-19 and were living in two distinct isolation centers in Khartoum, Sudan. This study's primary purpose was to find and analyse the prognostic importance of an independent set of biomarkers to anticipate the level of clinical severity and final outcome of COVID-19 infection.

In our study, 65 (71.5%) of the patients diagnosed as having severe or critical condition, and 52 (57.1%) died while in the hospital. This contrasts with the fact that approximately eighty percent of Chinese COVID-19 patients suffer from mild to moderate illnesses, fifteen percent have severe symptoms, and five percent have critical condition [4]. Furthermore, in the initial stages of the pandemic, the estimated case fatality rate for symptomatic patients was reported to be 17.3%, which declined to 0.7% over time [12, 13]. The difference in the prevalence of severe infection and death in the hospital in our study compared to others could be attributable to Sudanese patients delayed seek medical attention, limited resources, and a weak healthcare system. Furthermore, Individual risk characteristics, such as sex, advanced age, Asian and Black races, poverty, larger body mass index (BMI), and the presence of comorbidities, remain important indicator of illness severity and mortality [14, 15]. A retrospective research in China found that aged people with COVID-19 and comorbidities (most commonly atherosclerotic heart disease, hypertension, and longstanding respiratory conditions) had weaker immune function, higher rates of complications, and more severe disease [15]. High blood pressure was the most common comorbidity reported in this research, followed by diabetes and ischaemic heart disease.

Patient features and laboratory test results are both measurable and semantically relevant for measuring COVID-19 severity and mortality. Our study revealed statistically significant correlations between several independent variables (hemoglobin, total white blood cell count, C-reactive protein, neutrophil count, age, body mass index, lymphocyte count, , random blood sugar, neutrophil-lymphocyte ratio, serum creatinine, D-dimer, spontaneous oxygen saturation, and respiratory rate) and the clinical severity and/or outcome of infection. In our study, the patients had a mean age of 65.3 ± 12.1 years, and the majorities were males. Many others have noticed an increase in the severity and fatality rate of COVID-19 in older male patients [16, 17]. Low SpO2 levels (<92%) are associated with a greater risk of being admitted to the ICU, a state of acute respiratory distress, and septic shock [18]. Additionally, an admission SpO2 ≤78% has been linked to the need for mechanical ventilation in serious cases [19]. Elevated serum creatinine and CRP levels indicate acute renal damage and systemic vascular inflammation. The risk of death increases as the serum creatinine and CRP levels increase [20]. Furthermore, a prior study revealed that a slight increase in fasting blood glucose within the normal range was linked to a substantial increase in the likelihood of being admitted to the ICU [21]; hence, in line with many other studies, we advocate careful glycemic management upon admission [22].

Our findings indicate that the NLR is a significant predictor of the clinical severity and death of COVID-19. Increased neutrophil count, lower lymphocyte count, and higher peripheral neutrophil-to-lymphocyte ratio are inexpensive early indicators of COVID-19 severity and death [23-25]. Viral infections are known to directly diminish the number of lymphocytes, reducing cellular immunity. As the disease advances, arise in neutrophils and a corresponding reduction in lymphocytes cause the NLR to increase. Assessing the NLR can assist doctors in identifying potentially severe cases early, triaging them early, and initiating appropriate therapy promptly, thus decreasing total COVID-19 patient mortality [26].

Our research revealed that D-dimer levels are an independent indicator of infection severity and death. This agrees with the findings of previous systematic reviews and meta-analyses [27]. Excess amounts of D-dimer could worsen the effects of COVID-19, such as pulmonary thrombus development, thrombosis of deep veins, and diffuse intravascular coagulopathy, which are all associated with a poor prognosis [28].

Sudan is a resource-constrained country with a multicultural society and considerable ethnic diversity. These findings suggest that performing such a study and identifying simple predictors will decrease the severity of COVID-19 infection and improve the overall patient prognosis.

Strengths and limitations of the study

The study advocates for the use of several biomarkers that are compatible with our health resources and available in the majority of medical settings. However, our study has some drawbacks, one of which is the small sample size. Another limitation is that these data were collected on the first encounter with the health care provider;

however, follow-up would have greatly improved our study.

Conclusions

Our study identified several independent, inexpensive, simple, and important COVID-19 infection biomarkers (total white blood cell count, D-dimer, neutrophil count, random blood sugar, lymphocyte count, C-reactive protein, neutrophil–lymphocyte ratio, serum creatinine, spontaneous oxygen saturation, and respiratory rate) that can be used to stratify patients and allocate resources.

Declarations

Competing interests

The authors have no financial or nonfinancial competing interests to disclose.

Funding

Not applicable.

Availability of data and materials

The data generated in this study are available from the corresponding author upon reasonable request.

Consent to publication

Not applicable.

Acknowledgements

The authors are grateful to all the study participants.

References

1- World Health Organization (WHO). Coronavirus disease (COVID-19). (2023, August 9). https://www.who.int/news-room/fact-sheets/detail/coronavirus-disease-(covid-19).

2- Buitrago-Garcia D, Egli-Gany D, Counotte MJ, Hossmann S, Imeri H, Ipekci AM, et al. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. PLoS medicine. 2020 Sep 22;17(9):e1003346. https://doi.org/10.1371/journal.pmed.1003346

3- Clarke C, Prendecki M, Dhutia A, Ali MA, Sajjad H, Shivakumar O, et al. High prevalence of asymptomatic COVID-19 infection in hemodialysis patients detected using serologic screening. Journal of the American Society of Nephrology. 2020 Sep 1;31(9):1969-75. https://doi.org/10.1681/asn.2020060827

4- Surveillances V. The epidemiological characteristics of an outbreak of 2019 novel corona virus diseases (COVID-19)—China, 2020. China CDC weekly. 2020 Apr;2(8):113-22. https://doi.org/10.46234/ccdcw2020.032.

5- Tavakolpour S, Rakhshandehroo T, Wei EX, Rashidian M. Lymphopenia during the COVID-19 infection: What it shows and what can be learned. Immunology letters. 2020 Sep;225:31. https://doi.org/10.1016%2Fj.imlet.2020.06.013

6- Jimeno S, Ventura PS, Castellano JM, García-Adasme SI, Miranda M, Touza P, et al. Prognostic implications of neutrophil-lymphocyte ratio in COVID-19. European journal of clinical investigation. 2021 Jan;51(1):e13404. https://doi.org/10.1111/eci.13404

7- Al-Kuraishy HM, Al-Gareeb AI, Al-Hussaniy HA, Al-Harcan NA, Alexiou A, Batiha GE. Neutrophil Extracellular Traps (NETs) and Covid-19: A new frontiers for therapeutic modality. International immunopharmacology. 2022 Mar 1;104:108516. https://doi.org/10.1016/j.intimp.2021.108516

8- Zhang JJ, Cao YY, Tan G, Dong X, Wang BC, Lin J, et al. Clinical, radiological, and laboratory characteristics and risk factors for severity and mortality of 289 hospitalized COVID-19 patients. Allergy. 2021 Feb;76(2):533-50. https://doi.org/10.1111/all.14496

9- Pérez FM, Del Pino JL, García NJ, Ruiz EM, Méndez CA, Jiménez JG, et al. Comorbidity and prognostic factors on admission in a COVID-19 cohort of a general hospital. Revista Clínica Española (English Edition). 2021 Nov 1;221(9):529-35. https://doi.org/10.1016/j.rceng.2020.05.010

10- Anjorin AA, Abioye AI, Asowata OE, Soipe A, Kazeem MI, Adesanya IO, et al. Comorbidities and the COVID-19 pandemic dynamics in Africa. Tropical Medicine & International Health. 2021 Jan;26(1):2-13. https://doi.org/10.1111/tmi.13504

11- World Health Organization. Clinical management of COVID-19: living guidance. World Health Organization. 2021 Jan 25. https://iris.who.int/bitstream/handle/10665/338882/WHO-2019-nCoV-clinical-2021.1-eng.pdf

12- Mehta OP, Bhandari P, Raut A, Kacimi SE, Huy NT. Coronavirus disease (COVID-19): comprehensive review of clinical presentation. Frontiers in Public Health. 2021 Jan 15;8:582932. https://doi.org/10.3389/fpubh.2020.582932

13- National Health Commission. WHO-China Joint Mission on Covid-19 Final Report. https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf

14- Beaney T, Neves AL, Alboksmaty A, Ashrafian H, Flott K, Fowler A, et al. Trends and associated factors for Covid-19 hospitalization and fatality risk in 2.3 million adults in England. Nature Communications. 2022 Apr 29;13(1):2356. https://doi.org/10.1038/s41467-022-29880-7

15- Dai SP, Zhao X, Wu JH. Effects of comorbidities on the elderly patients with COVID-19: clinical characteristics of elderly patients infected with COVID-19 from sichuan, China. The Journal of nutrition, health and aging. 2021 Jan 1;25(1):18-24. https://doi.org/10.1007/s12603-020-1486-1

16- Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. The lancet. 2020 Feb 15;395(10223):507-13. https://doi.org/10.1016/s0140-6736(20)30211-7

17- Hall KS, Samari G, Garbers S, Casey SE, Diallo DD, Orcutt M, et al. Centering sexual and reproductive health and justice in the global COVID-19 response. The lancet. 2020 Apr 11;395(10231):1175-7.https://doi.org/10.1016/s0140-6736(20)30801-1

18- Shah S, Majmudar K, Stein A, Gupta N, Suppes S, Karamanis M, et al. Novel use of home pulse oximetry monitoring in COVID-19 patients discharged from the emergency department identifies need for hospitalization. Academic Emergency Medicine. 2020 Aug;27(8):681-92. https://doi.org/10.1111/acem.14053

19- Mukhtar A, Rady A, Hasanin A, Lotfy A, El Adawy A, Hussein A, et al. Admission SpO2 and ROX index predict outcome in patients with COVID-19. The American journal of emergency medicine. 2021 Dec 1;50:106-10. https://doi.org/10.1016/j.ajem.2021.07.049

20- Tian W, Jiang W, Yao J, Nicholson CJ, Li RH, Sigurslid HH, et al. Predictors of mortality in hospitalized COVID-19 patients: a systematic review and meta-analysis. Journal of medical virology. 2020

Oct;92(10):1875-83. https://doi.org/10.1002/jmv.26050

21- Alahmad B, Al-Shammari AA, Bennakhi A, Al-Mulla F, Ali H. Fasting blood glucose and COVID-19 severity: nonlinearity matters. Diabetes Care. 2020 Dec 1;43(12):3113-6. https://doi.org/10.2337/dc20-1941

22- Bastug A, Bodur H, Erdogan S, Gokcinar D, Kazancioglu S, Kosovali BD, et al. Clinical and laboratory features of COVID-19: Predictors of severe prognosis. International immunopharmacology. 2020 Nov 1;88:106950. https://doi.org/10.1016/j.intimp.2020.106950

23- Khartabil TA, Russcher H, van der Ven A, De Rijke YB. A summary of the diagnostic and prognostic value of hemocytometry markers in COVID-19 patients. Critical reviews in clinical laboratory sciences. 2020 Aug 17;57(6):415-31. https://doi.org/10.1080/10408363.2020.1774736

24- Wagner J, DuPont A, Larson S, Cash B, Farooq A. Absolute lymphocyte count is a prognostic marker in Covid-19: a retrospective cohort review. International journal of laboratory hematology. 2020 Dec;42(6):761-5. https://doi.org/10.1111/ijlh.13288

25- Moradi EV, Teimouri A, Rezaee R, Morovatdar N, Foroughian M, Layegh P, et al. Increased age, neutrophil-to-lymphocyte ratio (NLR) and white blood cells count are associated with higher COVID-19 mortality. The American journal of emergency medicine. 2021 Feb 1;40:11-4. https://doi.org/10.1016/j.ajem.2020.12.003

26- Li X, Liu C, Mao Z, Xiao M, Wang L, Qi S, et al. Predictive values of neutrophil-to-lymphocyte ratio on disease severity and mortality in COVID-19 patients: a systematic review and meta-analysis. Critical Care. 2020 Dec;24(1):1-0. https://doi.org/10.1186/s13054-020-03374-8

27- Malik P, Patel U, Mehta D, Patel N, Kelkar R, Akrmah M, et al. Biomarkers and outcomes of COVID-19 hospitalizations: systematic review and meta-analysis. BMJ evidence-based medicine. 2021 Jun 1;26(3):107-8. https://doi.org/10.1136/bmjebm-2020-111536

28- Klok FA, Kruip MJ, Van der Meer NJ, Arbous MS, Gommers DA, Kant KM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thrombosis research. 2020 Jul 1;191:145-7. https://doi.org/10.1016/j.thromres.2020.04.041

Yassin AS, Ali IA, Mohammed MA, Ahmed IA, Omer ND. COVID-19 infection in a resource-limited setting: Predictors of severity and mortality. Microbes Infect Dis 2025; 6(2): 444-454.