Original Article

Clinical Predictors of Covid-19 Mortality in a Tertiary Hospital in Lagos, Nigeria: A Retrospective Cohort Study

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Abstract

Background: The predictors of mortality among patients presenting with severe to critical disease in Nigeria are presently unknown. **Aim:** The aim of this study was to identify the predictors of mortality among patients with COVID-19 presenting for admission in a tertiary referral hospital in Lagos, Nigeria. **Patients and Methods:** The study was a retrospective study. Patients' sociodemographics, clinical characteristics, comorbidities, complications, treatment outcomes, and hospital duration were documented. Pearson's Chi-square, Fischer's Exact test, or Student's *t*-test were used to assess the relationship between the variables and mortality. To compare the survival experience across medical comorbidities, Kaplan Meir plots and life tables were used. Univariable and multivariable Cox-proportional hazard analyses were conducted. **Results:** A total of 734 patients were recruited. Participants' age ranged from five months to 92 years, with a mean ± SD of 47.4 ± 17.2 years, and a male preponderance (58.5% vs. 41.5%). The mortality rate was 9.07 per thousand person-days. About 73.9% (n = 51/69) of the deceased had one or more co-morbidities, compared to 41.6% (252/606) of those discharged. Patients who were older than 50 years, with diabetes mellitus, hypertension, chronic renal illness, and cancer had a statistically significant relationship with mortality. **Conclusion:** These findings call for a more comprehensive approach to the control of non-communicable diseases, the allocation of sufficient resources for ICU care during outbreaks, an improvement in the quality of health care available to Nigerians, and further research into the relationship between obesity and COVID-19 in Nigerians.

Keywords: *Clinical predictors, co-morbidity, COVID-19, Lagos, mortality*

Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] SARS-CoV-2 is closely related to SARS-CoV-1 and is believed to be of zoonotic origin.[2] Despite the fact that COVID-19 is primarily an infectious disease, it has been linked to a number of non-infectious consequences that are thought to be mediated by a variety of immune-related pathways.[3-6] Similarly, while it begins with respiratory symptoms, it eventually manifests with multisystemic complications.[7] Both the noninfectious and multisystemic consequences of COVID-19 have considerably contributed to the mortality reported among COVID-19-admitted patients.[5-7]

The spectrum of presentation of COVID-19 varies, and ranges from asymptomatic and mild, to severe and critical.[8] The illness may have a mild course with little

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or no symptoms, mimicking the common cold. In 3–4% of instances (7.4% for those over 65) the presentation requires hospitalization and intensive care unit (ICU) management. Mild cases typically recover within two weeks, however severe or critical disease may take three to six weeks.[5,7]

According to published literature from high-income countries and some low and middle-income countries, mortality among COVID-19 patients is associated with the severity of illness, age, and the presence of co-existing morbidities.[9-12] Given the high prevalence of human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), tuberculosis, and malaria, as well as malnutrition and high population density in urban informal settlements with poor hygiene and sanitation, COVID-19 mortality was expected to be high in Africa. However, reported mortality rates in Africa have been lower than previously anticipated.[13] A previous study of COVID-19- infected patients of all severity grades found that the severity of symptoms and signs at presentation, particularly in patients admitted with difficulty breathing, was the most significant clinical predictor of death.[14] However, the predictors of mortality among patients presenting with severe to critical disease in Nigeria are presently unknown.

The aim of this study was to identify the predictors of mortality among patients with moderate to severe COVID-19 infection that was admitted at a tertiary referral hospital in Lagos, Nigeria.

Methodology

Study design and study setting

The study was an observational retrospective cohort study of all children and adults admitted to the COVID-19 Isolation and Treatment Centre at the Lagos University Teaching Hospital (LUTH), Lagos, Nigeria, from April 2020 to October 2021. The LUTH COVID-19 isolation center is located within the LUTH complex and serves both children and adults. The LUTH COVID-19 Isolation and Treatment Centre was the only one in Lagos State established inside a multi-specialty tertiary hospital, with personnel and resources to treat severe and critical COVID-19 infections, including within an intensive care unit (ICU) setup.

Study population

All patients were admitted to the isolation ward of LUTH from April 2020 through October 2021.

Study procedure

The medical records of patients admitted for COVID-19 in the LUTH COVID-19 isolation center were examined. Using a case report form [Supplementary File 1], two members of the research team retrieved the following information from the medical records: sociodemographic information; clinical characteristics at presentation and during hospitalization; underlying chronic medical conditions and pre-existing chronic medications; hospital resource utilization or needs, such as the need for oxygen therapy, mechanical ventilation, and dialysis; duration of hospital stay; and the outcome of hospitalization.

Ethical consideration

The study got an exemption from the LUTH Health Research Ethics Committee (Approval number: LUTHHREC/EREV/0420/16) as a retrospective study and did not require informed consent because only medical information already documented in the patient's case record was reviewed. The study team did not contact the patients for the purpose of the study during the hospitalization or at any point during this study. We ensured that all extracted information bore no identifiers to the study participants; the names of participants were replaced with study ID. We ensured confidentiality by allowing access to de-identifiable extracted data to members of the study team who required access. In addition, the extracted information documented on the study proforma was stored in a locked cabinet; electronic databases derived from the study were pass-worded and access was limited to only those in the study team who needed access.

Statistical methods

Data were entered into an excel spreadsheet and then transferred to STATA version 16 (StataCorp, USA) statistical software for analysis. Data cleaning and validation were done. Descriptive statistics were conducted, and the frequency and percentages of the various outcomes was presented. Mean and standard deviation were reported for continuous variable while the median and interquartile range was reported for skewed continuous data. The association between categorical variables and each of the morbidity and mortality status was assessed using Pearson's Chi-square or Fischer's Exact test. Student's *t*-test was used to assess the difference between the mean age (and other continuous variables) of those that died and those that survived. The time-variate variable was the time to death or discharge while the outcome was mortality and those that survived were right-censored. Kaplan Meir plots and life Tables were conducted to compare the survival experience based on the various comorbidity. Univariable and multivariable Cox-proportional hazard was conducted. Variables with P values <0.2 were added in a backward elimination regression technique. Post regression Schoenfeld test was conducted to check for violation

of the assumptions of the model. Two models were built (Model I with age and model II did not have age). Two-tailed test of the hypothesis was assumed and a *P* value <0.05 was assumed to be statistically significant.

Results

Sociodemographic characteristics of study participants

Between April 2020 and October 2021, a total of 734 patients were admitted into the COVID-19 ward of the Lagos University Teaching Hospital. Participants' age ranged from five months to 92 years, with a mean ± SD of 47.4 ± 17.2 years. There was more male than female patients admitted for moderate to severe COVID-19 infection (58.5% vs. 41.5%).

Outcome of patients

As seen in Figure 1, 9.4% (95%CI: 7.43-11.85% (n = 69/734) of the individual's COVID-19 patients died during the research period. COVID-19-infected patients who died were about 12 years older than survivors (57.06 ± 17.57 years vs. 45.39 ± 16.70 years, *P* = 0.001). Additionally, approximately 73.9% (n = 51/69) of the deceased had one or more co-morbidities, compared to 41.6% (n = 252/606) of those who were discharged. Table 1 demonstrates that diabetes mellitus, hypertension, chronic renal disease, and cancer had statistically significant associations with mortality, whereas obesity, peptic ulcer disease, Sickle cell disease, congestive heart failure, asthma, and alcohol use did not.

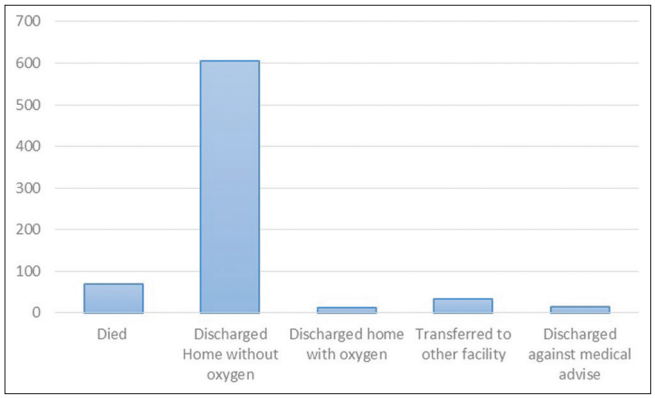

Figure 1: A bar chart of the outcome of patients admitted with COVID-19 in LUTH isolation wards from April 2020 – October 2021

Survival experience of COVID-19 patients

The total period of follow-up of the COVID-19 patients was 6,728 days while the mortality rate was 9.07 per thousand person-days [Supplementary Table 1]. About 95.3% (95%CI: 94.53-97.46%) of the patients survived beyond the first day of admission while about 88.3% survived beyond 10 days of admission. Those patients who were older than 50 years, or who had diabetes, hypertension, malignancy, or were admitted into ICU had poorer survival experience [Figure 2]; Supplementary Table 2.

On univariable regression, the hazard of death among COVID-19 patients that required ICU admission was about 7-fold as compared to patients that did not require ICU admission. (HR 6.6, 95%CI: 3.53 – 12.47, *P* value <0.001). The hazard of death was about 3 -fold among patients with comorbidity as compared to those without comorbidity. Furthermore, patients who were about 50 years and older had about a 3-fold hazard of death from COVID-19 infection as compared to the patients who were younger than 50 years.

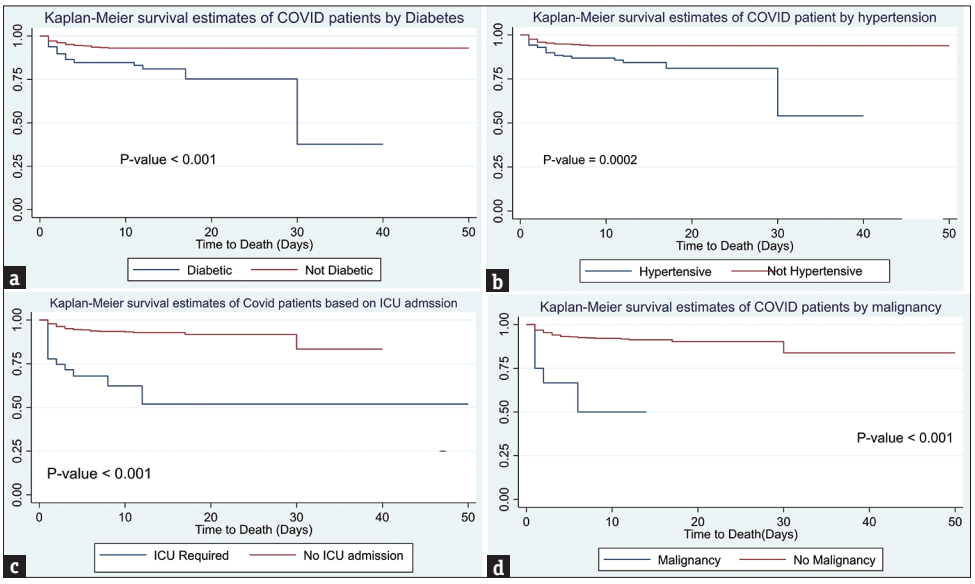

Figure 2: (a-d) Kaplan Meir Plots of the time to death of the COVID-19 participants overall and by diabetes mellitus, hypertension, malignancy, and intensive care unit admission status

Table 1: Association between co-morbidities and survival among COVID-19 patients

Characteristics (Co-morbidity)	Discharged home without oxygen	Dead	Total	*P*
Age (mean±SD) Years	45.39±16.70	57.06±17.57	46.54±17.13	<0.0001
<50	352 (58.1)	20 (28.9)	372 (55.1)	<0.001
≥50	254 (41.9)	49 (70.1)	303 (44.9)	
Morbidities				
Yes	252 (41.6)	51 (73.9)	303 (44.9)	<0.001
No	354 (58.4)	18 (26.1)	372 (55.1)	
Diabetes Mellitus				
Yes	94 (15.5)	29 (42.0)	123 (18.2)	<0.0001
No	512 (84.5)	40 (58.0)	552 (81.8)	
Hypertension				
Yes	199 (32.8)	41 (59.4)	240 (35.6)	<0.001
No	407 (67.2)	28 (40.6)	435 (64.4)	
CKD				
Yes	5 (0.82)	3 (4.3)	8 (1.2)	0.041
No	553 (99.2)	66 (95.7)	667 (98.8)	
Obesity				
Yes	11 (1.8)	4 (5.8)	15 (2.2)	0.111
No	595 (98.2)	65 (94.2)	660 (97.8)	
SCD				
Yes	5 (0.8)	2 (2.9)	7 (1.0)	0.400
No	601 (99.2)	67 (97.1)	668 (99.)	
HIV Status				
Yes	6 (1)	2 (2.9)	8 (1.2)	0.458
No	600 (99)	67 (97.1)	667 (98.8)	
Asthma status				
Yes	16 (3.1)	0 (0.00)	16 (2.4)	0.383
No	590 (96.9)	69 (100.00)	659 (97.6)	
Malignancy				
Yes	7 (1.2)	7 (10.1)	14 (2.1)	<0.001
No	599 (98.8)	62 (89.9)	661 (97.9)	
Heart failure				
Yes	10 (1.7)	4 (5.8)	14 (2.1)	0.100
No	596 (98.3)	65 (94.2)	599 (97.9)	
Cerebrovascular accident				
Yes	6 (1)	4 (5.8)	10 (1.5)	0.035
No	600 (99)	65 (94.2)	665 (98.5)	
Peptic Ulcer Disease				
Yes	20 (3.3)	2 (2.9)	22 (3.3)	1.000
No	586 (96.7)	67 (97.1)	653 (96.7)	
Hemiplegia				
Yes	4 (0.7)	3 (4.3)	7 (1)	0.078
No	602 (99.3)	66 (95.7)	668 (99)	
ICU requirement				
Yes	8 (1.5)	17 (24.6)	25 (3.7)	<0.001
No	597 (98.5)	22 (75.4)	650 (96.3)	
Alcohol use				
No	572 (94.4)	65 (93.55)	637 (94.4)	0.695
Yes	34 (5.6)	4 (6.45)	38 (5.6)	

After multivariable regression, the hazard of death from COVID-19 infection increases by about 3% for every annual increase in age [Table 2]. After correcting for confounding variables, patients with Diabetes mellitus had about 2- a fold hazard of death as compared to patients who were not diabetic (Adjusted HR: 2.4, 95% CI: 1.30- 4.51, *P* value = 0.006). Likewise, patients with a history of hypertension or malignancy had about 2-fold and 8.5-fold hazard of death as compared to those without hypertension or malignancy respectively.

Table 2: Univariable and Multivariable Cox proportional hazard ratio of the association between age and comorbidities and mortality from COVID-19 patients (Model II)

Characteristics	HR	95%CI	*P*	Adjusted HR	95%CI	*P*
Age	1.04	1.02-1.06	<0.001	1.03	1.01-1.05	0.012
<50	1.00	Reference	Reference			
≥50	2.83	1.62-4.93	<0.001			
Morbidity						
None	1.00	Reference	Reference			
Yes	3.20	1.83-5.60	<0.001			
Diabetes Mellitus						
Non-DM	1.00	Reference	Reference	1.00	Reference	Reference
DM	2.92	1.72-4.95	<0.001	2.04	1.10-3.79	0.024
Hypertension history						
Non-hypertensive	1.00	Reference	Reference	1.00	Reference	Reference
Hypertension	2.60	1.54-4.38	<0.001	1.24	0.63-2.44	0.527
Malignancy						
No history of malignancy	1.00	Reference	Reference	1.00	Reference	Reference
History of malignancy	7.58	3.24-17.73	<0.001	8.11	1.86-14.04	0.002
Obesity						
Non-obese	1.00	Reference	Reference	1.00	Reference	Reference
Obese	2.60	0.80-8.45	0.112	2.70	0.82-8.82	0.100
History of CKD						
None	1.00	Reference	Reference			
CKD	4.02	0.98-16.55	0.054			
History of SCD						
Non-SCD	1.00	Reference	Reference			
Sickle cell disease	2.41	0.33-17.44	0.383			
HIV status						
HIV Negative	1.00	Reference	Reference			
HIV Positive	1.62	0.22-11.69	0.634			
History of Congestive cardiac failure						
No CCF	1.00	Reference	Reference			
Congestive cardiac failure	1.40	0.19-10.10	0.741			
Peptic Ulcer Disease						
No	1.00	Reference	Reference			
Yes	0.60	0.08-4.34	0.613			
Hemiplegia						
No	1.00	Reference	Reference			
Yes	4.26	1.04-17.51	0.044			
Alcohol ingestion						
No	1.00	Reference	Reference			
Yes	0.94	0.22-3.95	0.934			
ICU Admission						
ICU not necessary	1.00	Reference	Reference			
ICU Necessary	6.64	3.53-12.47	<0.001			

The hazard of death among obese patients was not statistically different from the hazard of death among non-obese patients after correcting for confounding variables.

Discussion

Principal findings

In this retrospective cohort study, the medical records of 734 COVID patients admitted to a referral facility were examined to determine the mortality rate and the determinants of mortality. The study found a 9.4 percent death rate. In our patient cohort, age, diabetes, hypertension, chronic renal disease, cancer, and ICU admission were substantially linked with the hazard of death.

Strengths and limitations

The comparatively large sample size of patients presenting with the severe and critical diseases is

the primary strength of this study. Lagos State is the epicenter of the COVID-19 pandemic in Nigeria; and with LUTH being the largest referral center for cases that were complicated or required multi-specialist care, this cohort represented the largest single-center review of patients in Nigeria with severe and critical COVID-19.

However, because this is a single-center study, it has limitations. It is also retrospective in nature and is hospital-based. Furthermore, the follow-up duration was limited to the time spent in the hospital. There was no information on what happened to patients after they were discharged, transferred to another facility, or discharged against the medical recommendations.

Comparison with other studies

The present study revealed a mortality rate of 9.4%, which was higher than the global death rate for COVID-19,[15] as well as the death rates reported for the general population of Lagos State[16] and Nigeria.[17] However, our hospital's mortality rate was comparable to that of other referral hospitals that also admitted a large proportion of moderate to severe cases of COVID-19 patients as we did at our center.[18-20]

Globally, there has been a significant link between COVID-19-related death and increasing age, particularly among people over the age of 65.[21,22] In our cohort of patients, the risk of death increased by about 3% as they got older. It was discovered that people over the age of 50 had a higher risk of dying from COVID-19, which was consistent with data from other low-resource countries.[23-25] Low- and middle-income countries (LMICs) are believed to have a greater proportion of COVID-19 deaths at younger ages than high-income countries (HICs), with COVID-19 age-mortality curves in developing nations generally being flatter.[25]

Numerous studies have also demonstrated the association between mortality and the presence of comorbidities among COVID-19 patients.[14,18-20] Diabetes mellitus,[9,14,18] hypertension,[16,19] chronic kidney disease,[26,27] and cancer[28,29] have been shown to be strong predictors of COVID-19 death. This is consistent with the results of our study. As was also found in this study, no significant association was found between mortality and well-controlled asthma.[30] It is also believed that SCD is not an independent risk factor for COVID-19 death, as the haemoglobin genotype does not appear to be associated with the severity of COVID-19 disease.[31] Obesity was not a risk factor for mortality among our participants. This is contrary to research elsewhere, which has shown that obesity may be able to predict the risk and outcome for COVID-19 patients younger than 60 years of age.[32] Renal insufficiency, cardiovascular disease, Type 2 diabetes, certain cancers, and endothelial dysfunction are more prevalent among obese individuals.[33] These conditions increase the severity and mortality of COVID-19. In addition, obesity was believed to act independently to worsen the prognosis of COVID-19 patients, in part because adipose tissue impacts immune function.[34] Adipose tissue is a crucial endocrine organ that secretes Adipokines, Chemokines, and Cytokines, which influence metabolism and the immune system.[33-36] Thus, it is difficult to explain our finding that there is no correlation between obesity and COVID-19 mortality. More research is required to determine the link between obesity and COVID-19 mortality in Nigeria.

The association between the requirement for ICU care in our facility and death is consistent with findings elsewhere, which has been thought to be a reflection of the severity of COVID-19.[37,38] A meta-analysis to evaluate mortality rates of patients with COVID-19 in the ICU suggested that the poor outcomes seen in various studies may be related to the rationing of resources in overwhelmed ICUs, and not primarily to the severity of the underlying illness.[39] This was also observed in another study from Sweden that found higher death rates among COVID-19 patients admitted in the setting of increased admissions than when admission rates were lower.[40]

Interpretation of findings and implications

The predictors of mortality as found in our study demonstrate the similarity of the pattern of mortality determinants among patients with severe disease in both low- and high-income countries. However, there are subtle differences in our setting, both in terms of the lower absolute number of COVID-19 deaths and the relatively younger age of onset associated with increased mortality.

The association between lower at-risk age and COVID-19 mortality observed in this study reflects the pattern among LMICs and is believed to be a result of the Gompertz effect, which essentially means that population differences in mortality reflect the underlying population health and the quality of health care available to them.[41] The life expectancy in Nigeria is about 54 years, which is consistent with the finding in this study.[42]

In addition, the lack of a significant association between obesity and COVID-19 deaths among these patients appears to support the notion that obesity acts within a structure of added insult, such as an increased cardiovascular risk or an unfavorable immune

environment.[33,34] It is widely believed that common immunosuppressive conditions (such as malnutrition, tuberculosis, helminthic infections, and anemia) among Africans may provide protection against COVID-19,[43,44] as it is well known that hyperinflammation and other immunopathologic mechanisms play crucial roles in adverse outcomes among COVID-19-infected patients who are hospitalized. This postulation needs to be investigated further.

Conclusion

The study found that the mortality rate at a tertiary referral center was greater than that of the general Nigerian populace. Age, diabetes mellitus, hypertension, chronic renal disease, malignancy, and the necessity for ICU hospitalization were significantly associated with mortality. These findings call for a better approach to the control of non-communicable diseases (NCDs), as they have been shown to impact negatively during infectious disease outbreaks. Secondly, it is now clear that, as part of our epidemic preparedness planning, deliberate attempts must be made to ensure adequate resources are allocated to ICU capacity to ramp up care in the case of an outbreak. In the longer term, the quality of health care that is available to Nigerians must improve, to both increase the life expectancy of Nigerians, and also ensure a more robust response to emergencies. Further research is needed to identify the relationship between obesity and COVID-19 among Nigerian patients.

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Conflicts of interest

There are no conflicts of interest.

References

1. Gorbalenya AE, Baker SC, Baric RS, de Groot RJ, Drosten C, Gulyaeva AA, *et al*. Severe acute respiratory syndrome-related coronavirus: The species and its viruses–A statement of the coronavirus study Group. BioRxiv 2020. doi: 10.1101/2020.02.07.937862.
2. Rubens JH, Karakousis PC, Jain SK. Stability and viability of SARS-CoV-2. N Engl J Med 2020;382:1962-3.
3. Terpos E, Ntanasis-Stathopoulos I, Elalamy I, Kastritis E, Sergentanis TN, Politou M, *et al*. Hematological findings and complications of COVID-19. Am J Hematol 2020;95:834-47.
4. Lyons-Weiler J. Pathogenic priming likely contributes to serious and critical illness and mortality in COVID-19 via autoimmunity. J Transl Autoimmun 2020;3:100051. doi: 10.1016/j.jtauto.2020.100051.
5. Triggle CR, Bansal D, Ding H, Islam MM, Farag EA, Hadi HA, *et al*. A comprehensive review of viral characteristics, transmission, pathophysiology, immune response, and management of SARS-CoV-2 and COVID-19 as a basis for controlling the pandemic. Front Immunol 2021;12:631139. doi: 10.3389/fimmu.2021.631139.
6. Qian W, Ye Y, Zuo L, Song T, Xu Q, Wang Y, *et al*. Immune checkpoint inhibitors use and effects on prognosis of COVID-19 infection: A systematic review and meta-analysis. Immunotherapy 2021;13:1271-82.
7. Tsai PH, Lai WY, Lin YY, Luo YH, Lin YT, Chen HK, *et al*. Clinical manifestation and disease progression in COVID-19 infection. J Chin Med Assoc 2021;84:3-8.
8. World Health Organization. Living Guidance for Clinical Management of COVID-19. Geneva: World Health Organization; 2021. Available at https://apps.who.int/iris/bitstream/handle/10665/349321/WHO-2019-nCoV-clinical-2021.2-eng.pdf [Last assessed on 2022 Jun 30].
9. Singh AK, Gillies CL, Singh R, Singh A, Chudasama Y, Coles B, *et al*. Prevalence of co-morbidities and their association with mortality in patients with COVID-19: A systematic review and meta-analysis. Diabetes Obes Metab 2020;22:1915-24.
10. Eidininkienė M, Cesarskaja J, Talačkaitė S, Traškaitė-Juškevičienė V, Macas A. Mini review: Co-existing diseases and COVID-19—A one way ticket? Int J Environ Res Public Health 2022;19:4738. doi: 10.3390/ijerph19084738.
11. Ebinger JE, Achamallah N, Ji H, Claggett BL, Sun N, Botting P, *et al*. Pre-existing traits associated with Covid-19 illness severity. PloS One 2020;15:e0236240.
12. Gallo Marin B, Aghagoli G, Lavine K, Yang L, Siff EJ, Chiang SS, *et al*. Predictors of COVID-19 severity: A literature review. Rev Med Virol 2021;31:1-0. doi: 10.1002/rmv.2146.
13. Renzaho A. The need for the right socio-economic and cultural fit in the COVID-19 response in sub-Saharan Africa: Examining demographic, economic political, health, and socio-cultural differentials in COVID-19 morbidity and mortality. Int J Environ Res Public Health 2020;17:3445. doi: 10.3390/ijerph17103445.
14. Abayomi A, Odukoya O, Osibogun A, Wright O, Adebayo B, Balogun M, *et al*. Presenting symptoms and predictors of poor outcomes among 2,184 patients with COVID-19 in Lagos State, Nigeria. Int J Infect Dis 2021;102:226-32.
15. Baud D, Qi X, Nielsen-Saines K, Musso D, Pomar L, Favre G. Real estimates of mortality following COVID-19 infection. Lancet Infect Dis 2020;20:773.
16. Abayomi A, Osibogun A, Kanma-Okafor O, Idris J, Bowale A, Wright O, *et al*. Morbidity and mortality outcomes of COVID-19 patients with and without hypertension in Lagos, Nigeria: A retrospective cohort study. Glob Health Res Policy 2021;6:26. Erratum in: Glob Health Res Policy 2021;6:28.
17. Elimian K, Musah A, King C, Igumbor E, Myles P, Aderinola O, *et al*. COVID-19 mortality rate and its associated factors during the first and second waves in Nigeria. PLOS Global Public Health. 2022;2:e0000169.
18. Olivas-Martínez A, Cárdenas-Fragoso JL, Jiménez JV, Lozano-Cruz OA, Ortiz-Brizuela E, Tovar-Méndez VH, *et al*. In-hospital mortality from severe COVID-19 in a tertiary care center in Mexico City; causes of death, risk factors and the impact of hospital saturation. PloS One 2021;16:e0245772. doi: 10.1371/journal.pone.0245772.
19. Liu K, Fang YY, Deng Y, Liu W, Wang MF, Ma JP, *et al*. Clinical characteristics of novel coronavirus cases in tertiary hospitals in Hubei Province. Chin Med J 2020;133:1025-31.
20. Sheshah E, Sabico S, Albakr RM, Sultan AA, Alghamdi KS, Al Madani K, *et al*. Prevalence of diabetes, management and outcomes among Covid-19 adult patients admitted in a specialized tertiary hospital in Riyadh, Saudi Arabia. Diabetes Res Clin Pract 2021;172:108538. doi: 10.1016/j.diabres.2020.108538.
21. Mesas AE, Cavero-Redondo I, Álvarez-Bueno C,

Sarriá Cabrera MA, Maffei de Andrade S, Sequí-Dominguez I, *et al*. Predictors of in-hospital COVID-19 mortality: A comprehensive systematic review and meta-analysis exploring differences by age, sex and health conditions. PloS One 2020;15:e0241742. doi: 10.1371/journal.pone.0241742.

22. Sasson I. Age and COVID-19 mortality. Demogr Res 2021;44:379-96.
23. Chauvin JP, Fowler A, Herrera LN. The younger age profile of COVID-19 deaths in developing countries: IDB Working Paper Series. Washington, DC: Inter-American Development Bank (IDB); November 2020. Available at https://www.econstor.eu/bitstream/10419/237451/1/IDB-WP-1154.pdf [Last assessed on 2022 Jun 30].
24. Levin AT, Owusu-Boaitey N, Pugh S, Fosdick BK, Zwi AB, Malani A, *et al*. Assessing the burden of COVID-19 in developing countries: Systematic review, meta-analysis and public policy implications. BMJ Global Health 2022;7:e008477. doi: 10.1136/bmjgh-2022-008477.
25. Demombynes G. COVID-19 age-mortality curves are flatter in developing countries. Available from: https://openknowledge.worldbank.org/handle/10986/34028. [Last assessed on 2022 Jun 22].
26. Prabhakaran D, Singh K, Kondal D, Raspail L, Mohan B, Kato T, *et al*. Cardiovascular risk factors and clinical outcomes among patients hospitalized with COVID-19: Findings from the World Heart Federation COVID-19 study. Glob Heart 2022;17:40. doi: 10.5334/gh.1128.
27. Jassat W, Cohen C, Tempia S, Masha M, Goldstein S, Kufa T, *et al*. A national cohort study of COVID-19 in-hospital mortality in South Africa: The intersection of communicable and non-communicable chronic diseases in a high HIV prevalence setting. MedRxiv 2021:2020-12. doi: 10.1101/2020.12.21.20248409.
28. Chavez-MacGregor M, Lei X, Zhao H, Scheet P, Giordano SH. Evaluation of COVID-19 mortality and adverse outcomes in US patients with or without cancer. JAMA Oncol 2022;8:69-78.
29. Fernandes GA, Feriani D, e Silva IL, e Silva DR, Arantes PE, da Silva Canteras J, *et al*. Differences in mortality of cancer patients with COVID-19 in a Brazilian cancer center. Semin Oncol 2021;48:171-80.
30. Wang Y, Chen J, Chen W, Liu L, Dong M, Ji J, *et al*. Does asthma increase the mortality of patients with COVID-19? A systematic review and meta-analysis. Int Arch Allergy Immunol 2021;182:76-82.
31. Sayad B, Karimi M, Rahimi Z. Sickle cell disease and COVID-19: Susceptibility and severity. Pediatr Blood Cancer 2021;68:e29075. doi: 10.1002/pbc.29075.
32. Mohammad S, Aziz R, Al Mahri S, Malik SS, Haji E, Khan AH, *et al*. Obesity and COVID-19: What makes obese host so vulnerable? Immun Ageing 2021;18:1. doi: 10.1186/s12979-020-00212-x.
33. Palaiodimos L, Kokkinidis DG, Li W, Karamanis D, Ognibene J, Arora S, *et al*. Severe obesity is associated with higher in-hospital mortality in a cohort of patients with COVID-19 in the Bronx. New York. Metabolism 2020;108:154262. doi: 10.1016/j.metabol.2020.154262.
34. Gao F, Zheng KI, Wang XB, Sun QF, Pan KH, Wang TY, *et al*. Obesity is a risk factor for greater COVID-19 severity. Diabetes Care 2020;43:e72-4.
35. Chiappetta S, Sharma AM, Bottino V, Stier C. COVID-19 and the role of chronic inflammation in patients with obesity. Int J Obes 2020;44:1790-2.
36. Simonnet A, Chetboun M, Poissy J, Raverdy V, Noulette J, Duhamel A, *et al*. High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. Obesity (Silver Spring) 2020;28:1195-9.
37. Umeh C, Tuscher L, Ranchithan S, Watanabe K, Gupta R. Predictors of COVID-19 mortality in critically ill ICU patients: A multicenter retrospective observational study. Cureus 2022;14:e20952. doi: 10.7759/cureus.20952.
38. Reyes LF, Murthy S, Garcia-Gallo E, Irvine M, Merson L, Martin-Loeches I, *et al*. Clinical characteristics, risk factors and outcomes in patients with severe COVID-19 registered in the International Severe Acute Respiratory and Emerging Infection Consortium WHO clinical characterisation protocol: A prospective, multinational, multicentre, observational study. ERJ Open Res 2022;8. doi: 10.1183/23120541.00552-2021.
39. Quah P, Li A, Phua J. Mortality rates of patients with COVID-19 in the intensive care unit: A systematic review of the emerging literature. Crit Care 2020;24:285.
40. Strålin K, Wahlström E, Walther S, Bennet-Bark AM, Heurgren M, Lindén T, *et al*. Mortality in hospitalized COVID-19 patients was associated with the COVID-19 admission rate during the first year of the pandemic in Sweden. Infect Dis 2022;54:145-51.
41. Goldstein JR, Lee RD. Demographic perspectives on the mortality of COVID-19 and other epidemics. Proc Natl Acad Sci 2020;117:22035-41.
42. Lawanson OI, Umar DI. The life expectancy–economic growth nexus in Nigeria: the role of poverty reduction. SN Bus Econ 2021;1:1-26. doi: 10.1007/s43546-021-00119-9.
43. Cepon-Robins TJ, Gildner TE. Old friends meet a new foe: A potential role for immune-priming parasites in mitigating COVID-19 morbidity and mortality. Evol Med Public Health 2020;2020:234-48.
44. Głuchowska K, Dzieciątkowski T, Sędzikowska A, Zawistowska-Deniziak A, Młocicki D. The new status of parasitic diseases in the COVID-19 pandemic—risk factors or protective agents? J Clin Med 2021;10:2533. doi: 10.3390/jcm10112533.

Supplementary Table 1: Life Table of COVID-19 patients

Time	Beginning Total	Fail	Net Lost	Function	95% CI	
1	670	25	16	0.9627	0.9453	0.9746
2	629	10	14	0.9474	0.9275	0.9619
3	605	9	31	0.9333	0.9114	0.9499
4	565	5	23	0.9250	0.9020	0.9428
5	537	1	48	0.9233	0.9000	0.9413
6	488	4	35	0.9157	0.8913	0.9349
7	449	1	37	0.9137	0.8889	0.9331
8	411	1	41	0.9115	0.8863	0.9313
9	369	0	46	0.9115	0.8863	0.9313
10	323	1	71	0.9087	0.8828	0.9290
11	251	1	42	0.9050	0.8781	0.9263
12	208	1	36	0.9007	0.8722	0.9231
13	171	0	28	0.9007	0.8722	0.9231
14	143	0	19	0.9007	0.8722	0.9231
15	124	0	18	0.9007	0.8722	0.9231
16	106	0	13	0.9007	0.8722	0.9231
17	93	1	11	0.8910	0.8552	0.9184
18	81	0	7	0.8910	0.8552	0.9184
19	74	0	7	0.8910	0.8552	0.9184
20	67	0	11	0.8910	0.8552	0.9184
21	56	0	14	0.8910	0.8552	0.9184
22	42	0	2	0.8910	0.8552	0.9184
23	40	0	4	0.8910	0.8552	0.9184
24	36	0	7	0.8910	0.8552	0.9184
25	29	0	2	0.8910	0.8552	0.9184
27	27	0	4	0.8910	0.8552	0.9184
28	23	0	5	0.8910	0.8552	0.9184
29	18	0	4	0.8910	0.8552	0.9184
30	14	1	6	0.8274	0.6590	0.9175
31	7	0	1	0.8274	0.6590	0.9175
32	6	0	1	0.8274	0.6590	0.9175
34	5	0	1	0.8274	0.6590	0.9175
35	4	0	1	0.8274	0.6590	0.9175
40	3	0	2	0.8274	0.6590	0.9175
50	1	0	1	0.8274	0.6590	0.9175

Supplementary Table 2: Survival experience age and morbidity types						
Characteristics	**Time at risk**	**Mortality rate**	**Subjects**	**25%**	**50%**	**75%**
Overall	6,728	0.0090666	670	.	.	
Age						
<50	3,951	0.0045558	355	.	.	.
≥50	2,662	0.015402	304	.	.	.
Diabetes Mellitus						
Yes	1,177	0.0195412	129	30	30	.
No	5,384	0.006315	521	.	.	.
Hypertension						
Yes	2,156	0.0157699	242	30	.	.
No	4,420	0.0054299	411	.	.	.
Obesity						
Obese	148	0.0202703	13	.	.	.
Non-obese	6,118	0.0081726	607	.	.	.
Malignancy						
Malignancy	71	0.084507	12	1	6	.
Non Malignancy	6,393	0.0079775	629	.	.	.
ICU Admission						
ICU Required	267	0.0486891	36	2	.	.
ICU not required	6,148	0.0066688	599	.	.	.