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Predictors and outcomes of COVID-19 patients with hypoxemia in Lagos, Nigeria

Yeside Olubunmi Akinbolagbe[1,2], Erere Otrofanowei[3,4], Iorhen Ephraim Akase[4], Patricia E. Akintan[1,2], Uyiekpen E. Ima-Edomwonyi[4], Bolaji O. Olopade[4], Osigwe Paul Agabi[4], Danladi A. Nmadu[4], Gbemileke O. Akinbode[5], Adefolarin Opawoye[4], Aramide C. Olasope[4], Adewale Ogundare[4], Bukunmi A Bolarinwa[6], Elizabeth O. Otokiti[6], Precious J Enajeroh[4], Moses Karami[4], Chris Esezobor[1,2]

[1]Department of Paediatrics, College of Medicine, University of Lagos, [2]Department of Paediatrics, Lagos University Teaching Hospital, [3]Department of Medicine, College of Medicine, University of Lagos, Departments of [4]Medicine, [5]Surgery, [6]Haematology and Blood Transfusion, Lagos University Teaching Hospital, Lagos, Nigeria.

***Corresponding author:**
Yeside Olubunmi Akinbolagbe, Department of Paediatrics, College of Medicine, University of Lagos, and Lagos University Teaching Hospital, Lagos, Nigeria.

yesidekush@yahoo.com

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ABSTRACT

Objectives: The coronavirus disease 2019 (COVID-19) pandemic is the current public health concern. Hypoxemia has been identified as an independent risk factor for mortality in COVID-19 patients regardless of age or sex. This study therefore aimed to assess the profile of COVID-19 patients with hypoxemia in Lagos, Nigeria and identify their associated socio-demographic and clinical risk factors, predictors, and outcomes.

Materials and Methods: This was a retrospective cohort study in which data were extracted from medical records of real-time polymerase chain reaction confirmed COVID-19 positive patients admitted between April and October 2020. Data extracted included age, sex, comorbidities, disease category/classification, symptoms, lowest oxygen saturation (SPO2), and outcomes. Bivariate analysis was done to test associations between hypoxemia and other variables. Multivariate analysis was done to determine significant predictors of hypoxemia.

Results: A total of 266 patients were included in the study; mean (SD) 49.80 (± 16.68) years. Hypoxemia (lowest SPO2 ≤ 90 in adults and < 92% in children) was found in 102 (38.3 %) of the cases. SPO2 of hypoxemic patients ranged from 33% to 90%, Mean ±SD of 77±13%. About half of the hypoxemic cases, 53 (52%) were ≥ 60 years and mostly male 70 (68.6%). Difficulty breathing was present in 56 (55%), while the common comorbidities were hypertension 86 (32.3%) and diabetes mellitus 47 (17.7%). Age ≥ 60, difficulty breathing, and fever were independent predictors of hypoxemia. Hypoxemia was significantly associated with death (X^2-42.13; $P < 0.001$); odds ratio 14.5 (95% CI: 5.4–38.8).

Conclusion: Hypoxemia occurred in 1 out of every 3 COVID-19 patients with poor prognosis. SPO2 monitoring and early presentation in hospital for those 60 years and above or with dyspnea may be essential for early identification and treatment of hypoxemia to reduce mortality.

Keywords: Hypoxemia, Coronavirus disease 2019, Outcome, Risk factors, Nigeria

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic is the current public health concern ravaging the whole world since the first cases were discovered in Wuhan, China in December 2019.[1] This infectious disease caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-COV-2), affects people of all ages in various degrees, ranging from asymptomatic or mild disease in majority (81%) of cases, to severe (14%), and critical illness (5%) requiring intensive care and ventilation.[1]

Data on clinical presentation, course of illness and prognosis, are largely from studies done in China, Europe, and the United States of America (USA).[1-5] As COVID-19 cases are gradually increasing in parts of South America and Africa including Nigeria, it is important to examine the risk factors or predictors of severe disease and mortality in our setting to increase preparedness and management, considering the devastating impact it has had on the health system in high income countries.[6-8] This understanding will enable risk stratification and help to identify those who may likely need close monitoring and care. It would also allow channeling scarce resources and manpower toward those who would need them the most to potentially reduce morbidity and mortality.

Hypoxemia has been identified as an independent risk factor for mortality in COVID-19 patients regardless of age or sex.[3,9-11] A study in Israel reported that nasopharyngeal viral load predicted hypoxemia and that age and blood oxygen saturation were independently associated with mechanical ventilation and death.[12] Asymptomatic hypoxemia, which refers to a scenario where an individual has a reduced oxygen saturation (SPO2) indicating hypoxemia without having associated clinical features such as dyspnea or signs of respiratory distress, has also been associated with poor prognosis in COVID-19 patients.[13] Other risk factors for increased severity and mortality identified in other studies include older age, sex, dyspnea, and presence of comorbidities such as hypertension and diabetes mellitus (DM).[2,3,14,15] The role of these risk factors in the Nigerian setting has not been extensively reported.

This study, therefore, aimed to assess the profile of COVID-19 patients with hypoxemia in Lagos, Nigeria and identify their associated socio-demographic and clinical risk factors, predictors, and outcomes. This could provide the much-needed data, to inform COVID-19 case management and policy in Nigeria.

MATERIALS AND METHODS

Study design and location

This was a retrospective cohort study conducted at the Isolation ward of the Lagos University Teaching Hospital (LUTH). The LUTH is one of the Federal government tertiary hospitals and the largest tertiary hospital in Lagos state located in the South-western part of Nigeria, with a bed capacity of 760. It is a referral center for all levels of healthcare within and outside the state. The LUTH isolation ward has 120 beds and is one of the designated centers for treatment of COVID-19 patients in Lagos state. It has facilities for the treatment of both adults and children and serves the dual purpose of isolation of COVID-19 positive patients who are asymptomatic/mild to prevent spread of infection and treatment of those with moderate-severe disease.

Study participants

All patients with COVID-19 infection admitted into the LUTH isolation ward between April 2020 and October 2020 were eligible for the study. Inclusion criteria were real-time polymerase chain reaction confirmed COVID-19 positive cases with at least one oxygen saturation (SPO2) measurement taken during admission while cases with no recorded SPO2 measurement were excluded from the study. The primary outcome accessed in the study participants was hypoxemia; while the secondary outcomes were length of hospital stay, death (mortality), discharge, and transfer.

Ethics approval and consent to participate

Ethical approval was obtained from LUTH Health Research Ethics Committee (HREC), Reference No- LUTHHREC/EREV/0620/52. Data were extracted from the medical records; therefore, requirement of informed consent from participants was waived. Data were de-identified and handled responsibly to ensure patient privacy and confidentiality. Participants did not bear the cost of any study-related expenses.

Management of patients with confirmed COVID-19

Following the first case in Nigeria, all patients with confirmed SARS-CoV-2 infection, irrespective of the presence of symptoms, were admitted in hospital as part of a national strategy to contain the pandemic. Beginning from June 2020, with the number of patients outstripping available bed spaces in Lagos, admissions were limited to patients with moderate, severe, or critical COVID-19, or those unable to safely isolate at home. Until the last 3 weeks in June 2020, as part of the Centre's protocol, all patients with COVID-19 irrespective of severity of the disease received artemether-lumefantrine, ritonavir-boosted lopinavir, azithromycin, and ascorbic acid; for the rest of the study period, patient management was solely symptomatic unless the patient was enrolled in a clinical trial. Routine hematological and biochemical laboratory support of the management of the patients with COVID-19 was not established during the period covered in this report. Until the middle of May 2020, patients were discharged from hospital admission after clinical improvement (in symptomatic patients) and two consecutive negative PCR tests for SARS-CoV-2 performed at least 24 h apart; thereafter, discharge was based primarily on clinical improvement, or at least after 1 week of hospitalization if asymptomatic.

Data collection

The case notes of all the patients admitted into the LUTH Isolation ward for COVID-19 patients were reviewed. Data were also retrieved from a case reporting form that had been routinely filled for all positive COVID-19 patients who were admitted into the isolation wards, and those patients who met the inclusion criteria were included in the study.

Data extracted included socio-demographic data such as age and sex; and clinical data: Presence of comorbidity (hypertension, asthma, diabetes, human immunodeficiency virus infection, cancer, chronic obstructive pulmonary disease, obesity, etc.), disease category/classification (asymptomatic, mild, moderate, and severe), respiratory rate, and symptoms (cough, difficulty breathing, easy fatigability, fever, myalgia, sore throat, anosmia/ageusia, etc.).

The SPO2 reading/measurement on admission was retrieved and presence/absence of hypoxemia at admission assessed. Hypoxemia was defined as an SPO2 reading of ≤90% in adults and <92% in children. The charts of all cases were reviewed and the lowest SPO2 reading for each patient was recorded and used to determine if there was any episode of hypoxemia at any time during admission.

Outcomes such as length of hospital stay (before discharge or death), death, discharge, and transfer (to other institutions for intensive care unit [ICU] care or dialysis) were also retrieved. Length of hospital stay was classified as follows: Short (0–2 days); intermediate (3–10 days); and long (≥11 days). This classification was modified from data obtained from previous studies and authors' clinical experience.[16,17]

Classification of length of hospital stay by Wang *et al*. in the US[17] was short 0–5 days; medium 6–10 days and long ≥11 days, while study by Puozza[16] in Nigeria found median length of hospital stay to be 5 days. This data and authors' clinical observation of patient hospital stay in our institution was used to arrive at the modified classification used for this study.

Statistical analysis

Data were analyzed with the Statistical Package for the Social Sciences for Windows version 22. Frequency distribution tables were used for categorical variables. Continuous variables such as age and length of hospital stay were presented as means and standard deviations for normally distributed data and as median and interquartile range for skewed data.

Tests of association between categorical data were done using the Chi-square test or Fischer's exact test when expected value in any of the cells was less than five, while Pearson correlation was used for continuous variables such as age and SPO2 readings. Tests of association between outcomes (length of hospital stay and mortality) and hypoxemia were also done using Chi-square (X^2) test. Odds of outcome (mortality) were calculated for the variables, hypoxemia versus no hypoxemia. Multiple linear regression was used to determine significant risk factors and predictors of hypoxemia. $P < 0.05$ was considered as statistically significant at 95% confidence interval.

RESULTS

Baseline characteristics of study population

A total of 557 patients were managed between April 7 and October 7, 2020. Only 266 had SPO2 readings recorded and were analyzed. [Table 1] shows the baseline characteristics of the study population. The age of study population ranged between 7 and 86 years, mean ± SD of 49.80 ± 16.68 years. There were more males; 183 (68.8%) with a M: F ratio of 2.2:1. Most of the cases 99 (37.2%) were in the middle-aged age group (40–59 years) and 85 (32.2%) in the old age group (≥60 years).

About 185 (69.5%) of the cases had symptomatic disease; comorbidities were present in 127 (47.7%) of the study population. Disease category/severity was asymptomatic in 81 (30.5%) and severe in 79 (29.7 %) of the study population. SPO2 measurements ranged from 33% to 99%, Mean ± SD of 88 ±12%.

[Figures 1 and 2] show the spectrum of symptoms and comorbidities of the cases, respectively. The common

Table 1: Baseline characteristics of study population.

Variable	Frequency	(%) *n*=266
Age group (years)		
0–17	2	0.8
18–39	78	29.3
40–59	99	37.2
≥60	85	31.9
Not specified*	2	0.8
Sex		
Male	183	68.8
Female	83	31.2
Symptoms		
Present	185	69.5
Absent	81	30.5
Comorbidity		
Present	127	47.7
Absent	139	52.3
Disease category		
Asymptomatic	81	30.5
Mild	58	21.8
Moderate	43	16.2
Severe	79	29.7
Critical	5	1.9

*Exact age not recorded, stated as adult in medical records

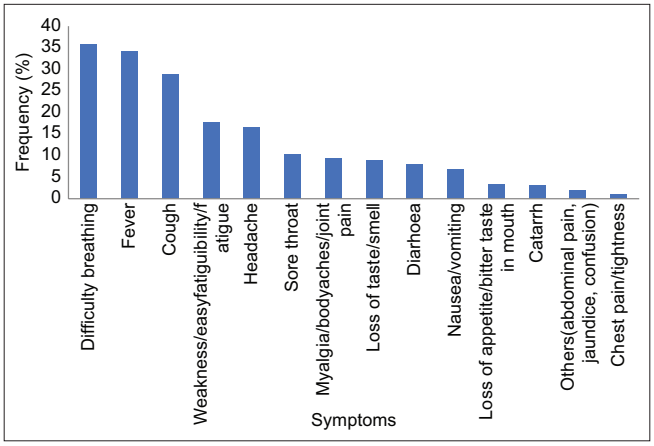

Figure 1: Spectrum of symptoms of cases.

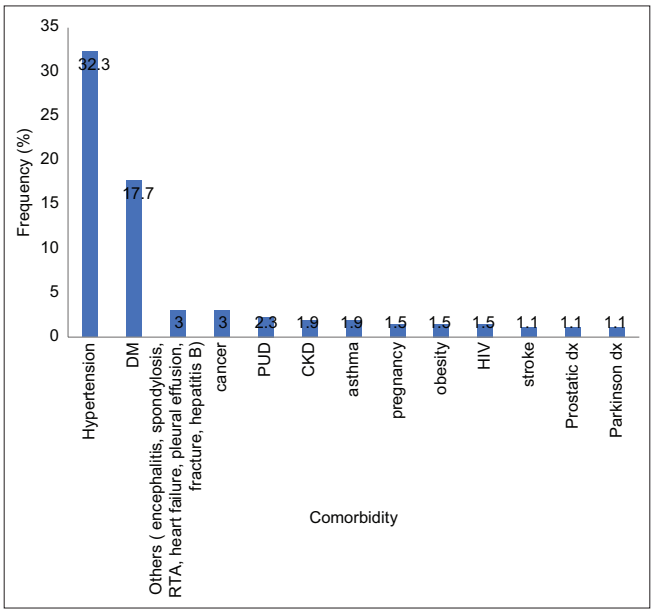

Figure 2: Spectrum of associated comorbidities.

symptoms were difficulty breathing in 95 (34.7), fever in 91 (34.2%) and cough in 77 (28.9%) of the cases; while the common comorbidities were: Hypertension; 86 (32.3%) and DM; 47 (17.7%).

Profile of hypoxemia cases

Hypoxemia (lowest SPO2 ≤90% in adults and <92% in children) was found in 102 (38.3%) cases. SPO2 measurements ranged from 33% to 90%, Mean ± SD of 77 ± 13%. The age of hypoxemic cases ranged from 20 to 86 years. The mean age ±SD of hypoxemic patients; 57.7 ± 15.4 years; was higher than that of the whole study population. About half of the cases, 53 (52%) were in the older age group of ≥60 years. There were more males than females 70 (68.6%) versus 32 (31.4%). Symptoms were present in 88 (86.3%) of them, while 66 (64.7%) had at least one comorbidity. Difficulty breathing was present in 56 (55%) of hypoxemia cases and was the most common symptom in them, while fever was the most common in non-hypoxemic cases 42 (25.6%).

Risk factors and predictors of hypoxemia

Association between demographic/clinical characteristics and hypoxemia

There was significant negative correlation between age and SPO2 of R= –0.33 (P = 0.001).

[Table 2] shows the association between demographic and clinical variables and hypoxemia.

On bivariate analysis (X^2 test), the following variables were significantly associated with hypoxemia; age ≥ 60 years, presence of symptoms, presence of comorbidity, symptoms: Cough, difficulty breathing and fever, and comorbidities: Hypertension and DM (P < 0.001). Cancer was more in hypoxemia cases; however, this difference was not statistically significant P = (0.06). Other symptoms and comorbidities were not found to be significantly associated with hypoxemia. Hypoxemic cases were more likely to be male, but this was not a statistically significant finding (P = 0.962).

Predictors of hypoxemia

[Table 3] shows the multiple regression analysis done to identify significant predictors of hypoxemia. The variables analyzed (age ≥ 60 years old, fever, cough, difficulty in breathing, DM, hypertension, presence of any symptom, and comorbidity) were collectively found to be significant (ANOVA F= 9.925; p< 0.001). However, the overall model fit was an adjusted R^2 of 0.212 showing that they were weak predictors of hypoxemia. The independent variables that remained significant predictors individually were age ≥ 60 (β = 0.232, P < 0.000), symptom of difficulty breathing (β = 0.224, P < 0.000), and fever (β = 0.136, P < 0.036).

Outcome

The outcome of the study population was discharged 222 (83.5%); died 37 (13.9%); and transferred 7 (2.6%). Most of the deaths 20 (54.1%) occurred within 48 hrs; 16 (43.2%) within 3–10 days; and 1 (2.7%) at ≥11 days.

The length of hospital stay ranged between 0 and 55 days with a mean (SD) of 11.4 (8) days.

Length of hospital stay was short (0–2 days) in 33 (12.4%) of cases, intermediate (3–10 days) in 101 (38%), and long (≥11 days) in 132 (49.6%) of cases.

The outcome of hypoxemic cases was as follows: 64 (62.7%) were discharged, 32 (31.4%) died, and 6 (5.9%) were

Table 2: Association between demographic/clinical characteristics and hypoxemia.

Variable	Hypoxemia (%)		Total *n*=266	X^2	*P*-value
	Yes	No			
Age group					
0–17	0 (0.0)	2 (100.0)	2	34.6	<0.001
18–39	15 (19.2)	63 (80.8)	78		
40–59	34 (34.3)	65 (65.7)	99		
≥60	53 (62.4)	32 (37.6)	85		
Age unspecified	0 (0.0)	2 (100.0)	2		
Sex					
Male	70 (38.3)	113 (61.7)	183	0.002	0.962
Female	32 (38.6)	51 (61.4)	83		
Symptoms					
Yes	88 (47.6)	97 (52.4)	185	21.85	<0.001
No	14 (17.3)	67 (82.7)	81		
Fever					
Yes	49 (53.8)	42 (46.2)	91	14.06	<0.001
No	53 (30.3)	122 (69.7)	175		
Cough					
Yes	42 (54.5)	35 (45.5)	77	12.02	<0.001
No	60 (31.7)	129 (68.3)	189		
Difficulty in breathing					
Yes	56 (58.9)	39 (41.1)	95	26.53	<0.001
No	46 (26.9)	125 (73.1)	171		
Comorbidity					
Yes	66 (52.0)	61 (48.0)	127	19.08	<0.001
No	36 (25.9)	103 (74.1)	139		
Cancer					
Yes	6 (75)	2 (25)	8		0.06*
No	96 (37.2)	162 (62.8)	258		
DM					
Yes	28 (59.6)	19 (40.4)	47	10.90	<0.001
No	74 (33.8)	145 (66.2)	219		
Hypertension					
Yes	49 (57)	37 (43.0)	86	18.66	<0.001
No	53 (29.4)	127 (70.6)	180		

*Fishers' exact test; $P<0.05$ is significant

Table 3: Multiple regression of hypoxemia (dependent variable) on independent variables.

Coefficients[a]					
Model	Standardized coefficients Beta (B)	t	*Sig	95% CI for B	
				Lower Bound	Upper Bound
(constant)		3.798	0.000	0.421	1.329
Age≥60 years	−0.224	−3.656	0.000	−0.357	−0.107
Difficulty breathing	0.232	3.664	0.000	0.109	0.363
Fever	0.136	2.106	0.036	0.009	0.270
Cough	0.080	1.260	0.209	−0.049	0.221
Symptoms present	0.015	0.200	0.842	−0.140	0.172
DM	0.032	0.498	0.619	−0.121	0.203
Comorbidity present	0.059	0.701	0.484	−0.104	0.219
Hypertension	0.057	0.699	0.485	−0.108	0.227

[a]Dependent variable: hypoxemia; *Sig (significance) – value<0.05 is significant

transferred to other centers for specialized care (intensive care and dialysis). [Table 4] shows outcome according to hypoxemic status. Most of the cases; 23 (69.7%); that had short hospital stay (0–2 days) were hypoxemic. The length of admission/hospital stay was significantly shorter for those with hypoxemia compared with those without hypoxemia ($P < 0.001$). The case fatality rate (CFR) for the whole study population was 13.9%; 31.4% in cases with hypoxemia and 3% in those without hypoxemia. Hypoxemia was significantly associated with death (X^2-42.13; $P < 0.001$); odds ratio (OR)-14.5 (95% CI: 5.4–38.8). Regarding timing of developing hypoxemia, 76 (74.5%) cases had hypoxemia at admission while 26 (25.5%) cases developed it later during admission. Cases with hypoxemia at time of admission were more likely to die 28 (36.8%) than those who developed hypoxemia later during their admission 4 (15.4%); OR 3.20 (95% CI: 1.00–10.26).

DISCUSSION

This study found hypoxemia determined by pulse oximeter measurements to affect about one-third of the COVID-19 cases. Seventy-six (28.6%) already had hypoxemia at the time of admission into hospital. The significant predictors of hypoxemia were fever, difficulty breathing, and old age ≥60 years. Although most of the hypoxemia cases were discharged, there was a high CFR of 31.4% among them. Hypoxemic cases had a significantly shorter length of hospital stay and odds of dying were 14 times higher compared to those without hypoxemia.

Similar findings of 28.9–41% of patients being hypoxemic on admission have been reported in studies in Nigeria and the US.[10,18] Patients with hypoxemia were likely to be older, male and had hypertension compared to those with SPO2 > 90% in our study which was consistent with the report from Wuhan, China.[11] However, association between hypoxemia and sex was not significant in the current study ($P = 0.96$) which was also corroborated by the Wuhan study. Studies from Nigeria and other countries agree with the finding of association between older age and severe COVID or hypoxemia.[5,19]

Table 4: Outcome according to hypoxemic status.

Variable	Hypoxemia (%)		(*n*=266)	X^2	*P*-value
	Yes	No			
Length of admission (days)					
Short (0–2)	23 (69.7)	10 (30.3)	33		
Intermediate (3–10)	28 (27.7)	73 (72.3)	101		
Long (≥11)	51 (38.6)	81 (61.4)	132	18.55	<0.001
Died					
Yes	32 (86.5)	5 (13.5)	37		
No	70 (30.6)	159 (69.4)	229	42.13	<0.001

Fever, dyspnea, cough, and DM were also found to be significantly associated with hypoxemia in this study. Fever, dyspnea, and cough are clinical features of inflammation and pneumonia which causes hypoxemia in COVID-19 patients, as less of the lung parenchyma becomes available for gaseous exchange.[20]

The relationship between hypoxemia and comorbidities differs among the various comorbidities, but the common denominator is the level of inflammation, with the result being acute respiratory distress syndrome. Some of the reasons may include increase in the expression of Angiotensin-converting enzyme 2 (ACE2) receptors, especially on the heart and blood vessels, leading to increased viral binding, and tissue pathology in hypertension.[21,22] Furthermore, hypertensive patients may be on ACE inhibitors, which have been linked with increase in the amount of ACE2 receptors that are expressed on the various end organs.[23] Furthermore, certain chronic conditions (e.g., DM and obesity) are associated with underlying inflammation, associated with endothelial dysfunction, and increased baseline inflammatory markers, predisposing them to a heightened inflammatory response to COVID-19 infection.[24] These findings are consistent with findings by Jang *et al*.[9] that reported association of fever and DM with hypoxemia. Ayinbuomwan *et al*.[25] also reported significant association of hypoxemia with dyspnea and presence of underlying disease. Conversely, only dyspnea was significantly associated with hypoxemia in a study in China.[11]

Other symptoms and comorbidities were not associated with hypoxemia in this study, which is contrary to other studies that have found some co-morbidities such as obesity[18,21,26] and cancer[27,28] to be associated with severe disease and hypoxemia. The disparity may be due to the small number of cases with these comorbidities in the current study. Cases with hypoxemia were also more likely to have symptoms and at least one comorbidity, compared with those without hypoxemia, which agrees with report by Xie *et al*.[11]

The independent predictors of hypoxemia in this study were fever, old age ≥ 60 and difficulty breathing. Other risk factors such as hypertension, diabetes, and cough though associated with hypoxemia were not significant predictors. It is, therefore, important to advocate for early presentation to hospital for those 60 years and above and those with dyspnea, as well as those with these symptoms and comorbidities, for they may be at increased risk of having hypoxemia necessitating the need for oxygen therapy. Early detection of hypoxemia and institution of oxygen therapy or ventilatory support could improve the prognosis of these cases.

In terms of outcomes, there was high overall mortality, or CFR of 13.9% in this study. This may be due to COVID-19 being a novel disease with paucity of effective therapies, especially earlier in the pandemic when there was poor

knowledge of the disease. Other studies done in Nigeria, China, and the US have found a range of between 2.6–33%.[5,11,14-19] These variations may exist due to the differences in cohorts of patients studied. Our study had a mix of asymptomatic and symptomatic patients with varied severity of illness, while some other studies like that of Buckner *et al*.[18] in the U.S. with a high CFR of 33%, had a population of patients who were older and had a high prevalence of comorbidities and severe disease. Furthermore, CFR was higher among hypoxemic patients (31.4%) compared to non-hypoxemic patients (3%) in this study. They were also 14 times more likely to die than those without hypoxemia. The relationship between hypoxemia and mortality may reflect the lack of COVID-19 ICU facilities during the 1st wave of the pandemic. There were very few ICUs in Lagos at that time, which were also expensive and not within the reach of many. Furthermore, hypoxemia contributes to the inflammatory process, thereby worsening the ventilation/perfusion V/Q mismatch, leading to worse outcomes.[29] Similar finding of higher mortality rate in hypoxemic versus non-hypoxemic cases of 68.6% versus 1.1% (Hazard ratio of 47) was obtained in study by Xie *et al*. in China.[11] They also reported that oxygen saturation (SPO2) >90.5% predicted survival with a sensitivity of 84.6% and specificity of 97.2%, and that dyspnea was independently associated with mortality.

A U.S. study[5] also reported 2 times greater odds of dying in hypoxemic patients. Similarly, a single center study in Northern Nigeria,[10] found that those with hypoxemia were 2.5 times more likely to die, though they had a small sample size of 45 cases, while a study in Lagos found dyspnea to be associated with increased mortality in COVID-19 patients but did not report oxygen saturation values.[14] Most of the deaths (54.1%) occurred within 48 hrs; 97% within 10 days, like median of 3 days (IQR 1–7) in a study by Elimian *et al*.[15] in Nigeria. Early mortality may be due to unavailability of facilities for ventilatory support or late presentation which has been reported in other studies from Nigeria.[14]

Timing of hypoxemia was also important, as those with hypoxemia on admission in hospital were 3 times more likely to die than those who developed it later during hospitalization. Similar finding was reported in a study in Korea among elderly COVID-19 patients in whom hypoxia on admission was associated with poor outcome and was a risk factor for ventilation and death.[30] Hypoxemia on admission would indicate a severe presentation which is often related to a poor outcome.

One out of every 3 COVID-19 cases in our cohort had hypoxemia. The implication of this is the increased need for oxygen therapy and possibly ventilation if this is not effective. Access to oxygen is limited in a resource poor country like ours[31] and COVID-19 increased the demand for an already scarce commodity. The impact of hypoxemia on mortality is huge as most studies including the current one have shown that it is one of the main predictors of mortality.

Objective measurement of oxygen saturation using the pulse oximeter is the easiest way to detect hypoxemia since it is easy to operate and portable. However, in our resource limited country, this seemingly inexpensive equipment may not be available to health facilities, let alone individuals. Therefore, early diagnosis of COVID-19 and presentation in hospital of at-risk individuals before severe hypoxemia develops cannot be over-emphasized.

Limitations

The limitations of this study are related to incomplete or unavailable records. Information about outcomes of patients transferred for specialist care was not available. Being a retrospective study and with absence of electronic medical records, some important parameters such as respiratory rate, laboratory, and radiologic investigations were not available for all the patients. Furthermore, SPO2 readings were not available or recorded in the case notes for all the patients and these had to be excluded from analysis. This may be due to the peculiarity of the isolation wards where case notes and charts are not taken to the patients' bedside to maintain infection control, or unavailability of pulse oximeters at patients' bedside. This study would have been more robust with more cases and inclusion of additional clinical and laboratory data.

CONCLUSION

Hypoxemia occurred in one out of every three patients with COVID-19 and they were 14 times more likely to die than those without hypoxemia. Fever, old age ≥ 60 years, and dyspnea were independent predictors of hypoxemia. Early presentation to hospital and SPO2 monitoring of COVID-19 cases with these features is essential for early identification of hypoxemia. Detecting and treating hypoxemia early could lead to a better prognosis.

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Declaration of patient consent

Patient's consent not required as patients, identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Wu Z, McGoogan JM. Characteristics of and important lessons from the Coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese center for disease control and prevention. JAMA 2020;323:1239-42.
2. Wu C, Chen X, Cai Y, Xia J, Zhou X, Xu S, *et al*. Risk factors associated with acute respiratory distress syndrome and death in patients with Coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med 2020;180:934-43.
3. 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;31:1-10.
4. Arentz M, Yim E, Klaff L, Lokhandwala S, Riedo FX, Chong M, *et al*. Characteristics and outcomes of 21 critically Ill patients With COVID-19 in Washington state. JAMA 2020;323:1612-4.
5. Mikami T, Miyashita H, Yamada T, Harrington M, Steinberg D, Dunn A, *et al*. Risk factors for mortality in patients with COVID-19 in New York city. J Gen Intern Med 2021;36:17-26.
6. World Health Organization (WHO) Coronavirus 2019 Situation Report-135. Data as Received by WHO from National Authorities by 10:00 CEST; 2020. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200603-covid-19-sitrep-135.pdf?sfvrsn=39972feb_2 [Last accessed on 2020 Jun 04].
7. Grasselli G, Pesenti A, Cecconi M. Critical Care Utilization for the COVID-19 outbreak in Lombardy, Italy: Early experience and forecast during an emergency response. JAMA 2020;323:1545-6.
8. White DB, Lo B. A framework for rationing ventilators and critical care beds during the COVID-19 pandemic. JAMA 2020;323:1773-4.
9. Jang JG, Hur J, Choi EY, Hong KS, Lee W, Ahn JH. Prognostic factors for severe Coronavirus disease 2019 in Daegu, Korea. J Korean Med Sci 2020;35:e209.
10. Ibrahim RO, Suleiman BM, Abdullahi SB, Oloyede T, Sanda A, Gbadamosi MS, *et al*. Epidemiology of COVID-19 and predictors of outcome in Nigeria: A single-center study. Am J Trop Med Hyg 2020;103:2376-81.
11. Xie J, Covassin N, Fan Z, Singh P, Gao W, Li G, *et al*. Association between hypoxemia and mortality in patients with COVID-19. Mayo Clin Proc 2020;95:1138-47.
12. Shlomai A, Ben-Zvi H, Bendersky AG, Shafran N, Goldberg E, Sklan EH. Nasopharyngeal viral load predicts hypoxemia and disease outcome in admitted COVID-19 patients. Crit Care 2020;24:539.
13. Brouqui P, Amrane S, Million M, Cortaredona S, Parola P, Lagier JC, *et al*. Asymptomatic hypoxia in COVID-19 is associated with poor outcome. Int J Infect Dis 2021;102:233-8.
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. Elimian KO, Ochu CL, Ebhodaghe B, Myles P, Crawford EE, Igumbor E, *et al*. Patient characteristics associated with COVID-19 positivity and fatality in Nigeria: Retrospective cohort study. BMJ Open 2020;10:e044079.
16. Puozaa CY. The determinants of hospital length of stay in Nigeria. Int J Bus Econ Sci Appl Res 2016;9:34-42.
17. Wang D, Courtemanche-Martel S. Understanding Patient Hospital Stays: A Classification and Clustering Analysis in R: An Application of Machine Learning Methods to Patient Hospitalization Records; 2021. Available from: https://www.towardsdatascience.com/understanding-patient-hospital-stays-a classification-and clustering-analysis-in-r-bba200c9323 [Last accessed on 2021 Aug 10].
18. Buckner FS, McCulloch DJ, Atluri V, Blain M, McGuffin SA, Nalla AK, *et al*. Clinical features and outcomes of 105 hospitalized patients with COVID-19 in Seattle, Washington. Clin Infect Dis 2020;71:2167-73.
19. Otuonye NM, Olumade TJ, Ojetunde MM, Holdbrooke SA, Ayoola JB, Nyam IY, *et al*. Clinical and demographic characteristics of COVID-19 patients in Lagos, Nigeria: A descriptive study. J Natl Med Assoc 2020;113:301-6.
20. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, *et al*. Clinical characteristics of 138 hospitalized patients with 2019 novel Coronavirus-infected pneumonia in Wuhan, China. JAMA 2020;323:1061-9.
21. South AM, Diz DI, Chappell MC. COVID-19, ACE2, and the cardiovascular consequences. Am J Physiol Heart Circ Physiol 2020;318:H1084-90.
22. Kow CS, Zaidi STR, Hasan SS. Cardiovascular disease and use of renin angiotensin system inhibitors in COVID-19. Am J Cardiovasc Drugs 2020;20:217-21.
23. Ferrario CM, Jessup J, Chappell MC, Averill DB, Brosnihan KB, Tallant, EA, *et al*. Effect of angiotensin-converting enzyme inhibition and angiotensin II receptor blockers on cardiac angiotensin-converting enzyme 2. Circulation 2005;111:2605-10.
24. Guo W, Li M, Dong Y, Zhou H, Zhang Z, Tian C, *et al*. Diabetes is a risk factor for the progression and prognosis of COVID-19. Diabetes Metab Res Rev 2020, April 7;e3319.
25. Ayinbuomwan SA, Mokogwu N, Akoria OA, Okwara BU, Omuemu CE, Obaseki DE. Arterial oxygen saturation and other clinical predictors of survival in patients with COVID-19: A review of cases in a tertiary care hospital in Nigeria. West Afr J Med 2021;38:109-13.

26. Hernández-Garduño E. Obesity is the comorbidity more strongly associated for COVID-19 in Mexico. A case-control study. Obes Res Clin Pract 2020;14:375-9.
27. Liang W, Guan W, Chen R, Wang W, Li J, Xu K, *et al*. Cancer patients in SARS-CoV-2 infection: A nationwide analysis in China. Lancet Oncol 2020;21:335-7.
28. Zhang L, Zhu F, Xie L, Wang C, Wang J, Chen R, *et al*. Clinical characteristics of COVID-19-infected cancer patients: A retrospective case study in three hospitals within Wuhan, China. Ann Oncol 2020;31:894-901.
29. Lazzerini M, Sonego M, Pellegrin MC. Hypoxaemia as a mortality risk factor in acute lower respiratory infections in children in low and Middle-income countries: Systematic review and meta-analysis. PLoS One 2015;10:e0136166.
30. Lee JY, Kim HA, Huh K, Hyun M, Rhee JY, Jang S, *et al*. Risk factors for mortality and respiratory support in elderly patients hospitalized with COVID-19 in Korea. J Korean Med Sci 2020;35:e223.
31. Ikhisemojie S. Patients Dying from Lack of Oxygen in Nigerian Hospitals; 2018. Available from: https://www.punchng.com/patients-dying-from-lack-of-oxygen-in-nigerian-hospitals [Last accessed on 2021 Mar 22].

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