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## Predictors of severe hypoxemia among COVID-19 patients in Burkina Faso (West Africa): Findings from hospital based cross-sectional study



Eric Arnaud Diendéré<sup>a,\*</sup>, Kongnimissom Apoline Sondo<sup>b</sup>, Abdoul Risgou Ouédraogo<sup>c</sup>, Désiré Lucien Dahourou<sup>d</sup>, Kadari Cissé<sup>d</sup>, Abdoulaye Sawadogo<sup>e</sup>, Soumaila Maiga<sup>f</sup>, Marcel Kuiré<sup>g</sup>, Seidou Zida<sup>g</sup>, Pierre R. Kaboré<sup>g</sup>, Christian J.W. Minoungou<sup>c</sup>, Ulrich Habou<sup>a</sup>, Habil Badalo<sup>a</sup>, Noelie Zoungrana<sup>h</sup>, Arsène G. Ouédraogo<sup>b</sup>, Arielle Rita Belem<sup>i</sup>, Jacques Zoungrana<sup>i</sup>, Armel Poda<sup>i</sup>, Ismael Diallo<sup>b</sup>, Flavien Kaboré<sup>j</sup>, Adama Sanou<sup>h</sup>, Séni Kouanda<sup>d</sup>

<sup>a</sup> Internal Medicine Department, Bogodogo Teaching Hospital, Ouagadougou, Burkina Faso

<sup>b</sup> Infectious Diseases Department, Yalgado Ouédraogo Teaching Hospital, Ouagadougou, Burkina Faso

<sup>c</sup> Medicine Department, Tengandogo Teaching Hospital, Ouagadougou, Burkina Faso

<sup>d</sup> Department of Biomedical and Public Health, Research Institute of Health Sciences, Ouagadougou, Burkina Faso

<sup>e</sup> Infectious Diseases Department, Ouahigouya Teaching Hospital, Ouahigouya, Burkina Faso

<sup>f</sup> Pneumology Department, Ouahigouya Teaching Hospital, Ouahigouya, Burkina Faso

<sup>g</sup> Internal Medicine Department, Pissy District Hospital, Ouagadougou, Burkina Faso

<sup>h</sup> Directorate of Medical and Technical Services, Tengandogo Teaching Hospital, Ouagadougou, Burkina Faso

<sup>i</sup> Infectious Diseases Department, Souro Sanon Teaching Hospital, Bobo-Dioulasso, Burkina Faso

<sup>j</sup> Anaesthesia and Resuscitation Department, Tengandogo Teaching Hospital, Ouagadougou, Burkina Faso

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### ABSTRACT

**Introduction:** COVID-19 is one of the world's major health crises. The objective of this study was to determine the predictive factors of severe hypoxemia in patients hospitalized in COVID-19 health facilities in Burkina Faso.

**Patients and method:** This study was a hospital-based cross-sectional study. The data collected relate to the period of the first wave of the epidemic (March 9 to June 30, 2020). All patients hospitalized for COVID-19 in the requisitioned health facilities of Ouagadougou were included in this study. Predictors of severe hypoxemia were identified using a multivariate logistic regression model.

**Results:** During the study period, 442 patients were included, representing 45.7% of the total number of positive patients in the entire country. The most common co-morbidities were diabetes (55; 12.4%) and arterial hypertension (97; 21.9%). Severe hypoxemia (SpO<sub>2</sub> < 90%) was observed in 64 patients (14.5%). Age over 65 years (OR = 8.24; 95% CI: 2.83–24.01) and diabetes (OR = 2.43; 95% CI: 1.17–5.06) were the predictors for occurrence of severe hypoxemia in multivariate analysis.

**Conclusion:** The predictive factors of COVID-19 are similar in African and Caucasian populations. The surveillance of COVID-19 in risk groups should be strengthened to reduce their morbidity and mortality.

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\* Corresponding author at: Bogodogo Teaching Hospital, 06 BP: 10780 Ouagadougou 06, Burkina Faso.

E-mail addresses: [ericarno@hotmail.fr](mailto:ericarno@hotmail.fr) (E.A. Diendéré), [sondoapoline@yahoo.fr](mailto:sondoapoline@yahoo.fr) (K.A. Sondo), [oarisgou@yahoo.fr](mailto:oarisgou@yahoo.fr) (A.R. Ouédraogo), [ddahourou@gmail.com](mailto:ddahourou@gmail.com) (D.L. Dahourou), [cisskad4@gmail.com](mailto:cisskad4@gmail.com) (K. Cissé), [sawadogo.abdoulaye.bf@gmail.com](mailto:sawadogo.abdoulaye.bf@gmail.com) (A. Sawadogo), [maigas01@yahoo.fr](mailto:maigas01@yahoo.fr) (S. Maiga), [mkuire@yahoo.fr](mailto:mkuire@yahoo.fr) (M. Kuiré), [zidasei@yahoo.fr](mailto:zidasei@yahoo.fr) (S. Zida), [peterkabor@yahoo.fr](mailto:peterkabor@yahoo.fr) (P.R. Kaboré), [ouagamjcw@yahoo.fr](mailto:ouagamjcw@yahoo.fr) (C.J.W. Minoungou), [haboubenulrich8@gmail.com](mailto:haboubenulrich8@gmail.com) (U. Habou), [habilbadalo@gmail.com](mailto:habilbadalo@gmail.com) (H. Badalo), [wnoelie@yahoo.fr](mailto:wnoelie@yahoo.fr) (N. Zoungrana), [gafourouarsene@gmail.com](mailto:gafourouarsene@gmail.com) (A.G. Ouédraogo), [belemarielle@gmail.com](mailto:belemarielle@gmail.com) (A.R. Belem), [zojacques@yahoo.fr](mailto:zojacques@yahoo.fr) (J. Zoungrana), [armelpoda@yahoo.fr](mailto:armelpoda@yahoo.fr) (A. Poda), [illah\\_diallo@hotmail.com](mailto:illah_diallo@hotmail.com) (I. Diallo), [kflavien72@yahoo.fr](mailto:kflavien72@yahoo.fr) (F. Kaboré), [sanoua14@yahoo.fr](mailto:sanoua14@yahoo.fr) (A. Sanou), [senikouanda@gmail.com](mailto:senikouanda@gmail.com) (S. Kouanda).

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### Introduction

Coronavirus disease-19 (COVID-19) is one of the world's major health crises. As of January 22, 2021, this disease had affected 219 countries with a total of 98.167.437 cases, including 2.102.368 deaths worldwide (Worldometer, 2021). The disease is benign in the majority of cases, but in 14% of cases is severe (Verity et al., 2020). There are various severe forms, of which respiratory failure is the most common (Fisher, 2020; Varghese et al., 2020). Depending on the studies, the frequency of severe respiratory forms ranges from 8% to 67% (Khateri et al., 2020; Xie et al., 2020). Those forms may lead to multi-organ failure, requiring mechanical ventilation and transfer to intensive care unit (ICU). The WHO definition of severe respiratory forms includes hypoxemia with pulsed oxygen saturation (SpO2) less than 90% (World Health Organisation, 2020). Different theories have been put forward to explain respiratory failure. Respiratory inflammation due to cytokine storm and vasculitis are the main elements involved in the occurrence of respiratory distress (Revzin et al., 2020).

Factors associated with the unfavorable evolution of COVID-19 have been variously described in studies. Thus, age over 60 years, and co-morbidities such as diabetes, hypertension, chronic lung disease and cancer have been identified as risk factors for hypoventilation, use of mechanical ventilation and death (Rodríguez-Molinero et al., 2020; Russell et al., 2020). Ethnicity and social factors have been described in some studies as potentially influencing disease severity (Patel et al., 2020a; Vahidy et al., 2020). However, a great majority of these studies have been

conducted in the United States, Asia and Europe, with few studies in resource-limited countries (Dondorp et al., 2020).

Burkina Faso reported its first cases of COVID-19 on March 9, 2020 and registered 967 cases of the disease as of June 30, 2020 (Health response operations center (CORUS), Ministry of Health (Burkina Faso), 2020). As of January 22, 2021, the two biggest cities (Ouagadougou and Bobo-Dioulasso) accounted for 91.5% of all cases. Hospitalization of all cases was a government measure, and patients were mostly admitted to the requisitioned health facilities. The objective of this study was to determine the prevalence of severe hypoxemia at admission and its predictive factors in COVID-19 health facilities in Ouagadougou, Burkina Faso.

### Patients and methods

#### Study design and settings

This study was a hospital-based cross-sectional study. The data collected relate to the period of the first wave of the epidemic, which extended from March 9 to June 30, 2020. The two centers, namely the Tengandogo Teaching Hospital and Princess Sarah Clinic, requisitioned for the exclusive management of COVID-19 cases regardless of the severity of the disease were the study sites. Tengandogo Teaching Hospital is a tertiary level hospital with 250 beds and a resuscitation unit equipped with 7 functional beds. Princess Sarah Clinic is a non-profit health facility with 45 functional beds. The patients who required respiratory assistance were systematically taken to Tengandogo Teaching Hospital.

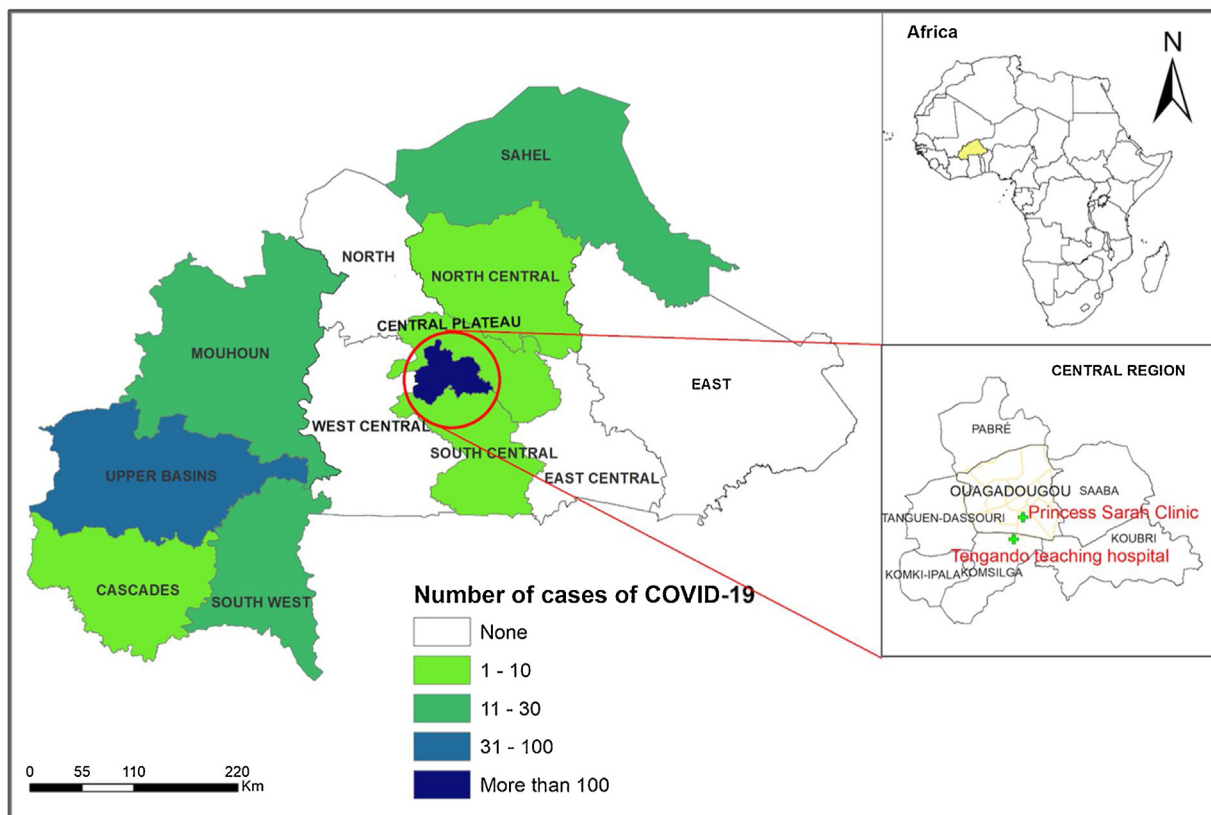


Figure 1. Mapping of COVID-19 cases in Burkina Faso during the first wave of the epidemic (March 9 to June 30, 2020).

From March 9 to June 30, 2020, 967 patients tested positive for SARS-CoV-2 throughout the country, including 804 (81.1%) cases in Ouagadougou. The five (5) health districts of the Central region were the most affected (Figure 1).

#### Study population and inclusion criteria

All patients hospitalized at the two centers were included in this study. A confirmed case of COVID-19 was defined by a positive result on a Reverse transcriptase - Polymerase chain reaction (RT-PCR) assay of a specimen collected on a nasopharyngeal and oropharyngeal swab. The RT-PCR kit used for the diagnosis of SARS-Cov-2 was Tib-Molbiol LightMix<sup>®</sup> (Berlin, Germany) for the detection of E, N and RdRp genes. Only laboratory-confirmed cases were included.

Patients who died on admission for whom clinical data were incomplete were not included.

#### Data collection

Multidisciplinary healthcare teams (medical and paramedical health workers as well as support staff) were requisitioned to follow up patients with a rotation every 24 h. The monitoring system included assessment of clinical vitals including temperature, heart rate, respiratory rate, blood pressure and transcutaneous measurement of pulse O<sub>2</sub> saturation by pulse oximeter (Dinamap<sup>®</sup> DPC320N-CE or Fingertrip pulse Oximeter<sup>®</sup>, Concord Health Supply). The data were registered on medical records and an Excel database.

The variables collected were: socio-demographic characteristics (age, sex, place of residence), clinical features (mode of referral and entry of patients, clinical signs, co-morbidities), biological data (SARS Cov-2 PCR, hematology, biochemistry) and patients' outcomes. In our analysis, we used severe hypoxemia as main outcome variable, defined as peripheral capillary oxygen saturation (SpO<sub>2</sub>) less than 90%.

The socio-economic level of the patients was defined as follows:

- low: manual workers, farmers, retail traders, and casual urban workers.
- intermediate: State and/or private sector employees and middle-level traders.
- high: senior State and/or private sector executives and import-export traders.

#### Data analysis

Quantitative variables were described by their median and interquartile range. Qualitative variables were described by their frequency. The statistical comparisons were made using the Chi-2 test or the Fisher exact test when the Chi-2 conditions were not met. Predictive factors associated with severe hypoxia were identified by logistic regression. In univariate analysis, the predictive factors with a p-value less than 0.25 were included in the multivariate model. The final model was obtained by a manual stepwise descending strategy, removing at each step the covariate not associated with the 5% threshold. The significance threshold in the final model was set at 5%. Analyses were performed using SAS 9.4 software (Cary, NC).

#### Ethical considerations

The study has been approved by the National Research Ethics Committee for health sciences (CERS) under number 2020-9-214. The use of routine data did not warrant consent under local current regulations. The heads of the selected facilities were informed prior to the study about the purpose and conditions of the study. The data were anonymously collected on a paper questionnaire to ensure confidentiality according to the ICHGCP standards.

#### Results

##### Geographical distribution and socio-demographic description of COVID-19 cases

During the study period, 442 patients were included representing 45.7% of the total number of positive patients in the entire country. The number of admissions was 110 patients for the month of March, 184 for the month of April, 142 for the month of May and 5 for the month of June. Figure 2 shows the trend of hospitalizations between March 9 (date of occurrence of the first case) and June 30, 2020.

The median age was 42 years (interquartile range (IIQ): Q<sub>1</sub> = 27–Q<sub>3</sub> = 57) (Table 1). Male patients represented 62.4%; 48.9% of patients were in the middle class for the socioeconomic status.

##### Clinical features

The most common co-morbidities were diabetes (55; 12.4%), Arterial hypertension (97; 21.9%) and chronic respiratory disease (20; 4.5%) (Table 2).

Active smoking was not common (6; 1.4%).

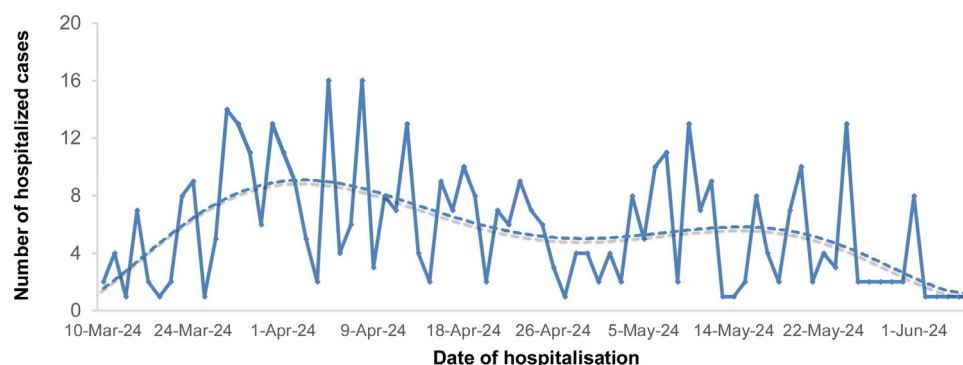


Figure 2. Frequency of hospitalization of patients infected with SARS-CoV-2 at treatment centers from March 9 to June 30, 2020.

**Table 1**  
Socio-demographic characteristics of SARS-Cov-2 infected patients.

Features	N	%
Sex		
- Male	275	62.4
- Female	166	37.6
Age group (in years)		
- 9–24	78	18.1
- 25–49	172	40.0
- 50–64	126	29.3
- More than 65	54	12.6
Socio-economic level <sup>a</sup>		
- Low	167	42.7
- Intermediate	191	48.9
- High	33	8.4

- Low: manual workers, farmers, retail traders, and casual urban workers.

- Intermediate: State and/or private sector employees and middle-level traders.

- High: senior State and/or private sector executives and import-export traders.

<sup>a</sup> Socio-economic level.

Among the clinical signs reported by patients on admission or during their hospitalization, fever or chills (246; 55.7%), cough (186; 42.1%), rhinorrhea (74; 16.7%), and headache (74; 16.7%) were the most frequent. Respiratory distress was observed at admission in 12 patients (2.7%) and altered consciousness (Glasgow coma scale < 15) was reported in 10 patients (2.3%).

The hemodynamic parameters recorded showed Systolic Blood Pressure (SBP) < 100 mmHg for 31 patients (8.5%), and Diastolic Blood Pressure (DBP) < 60 mmHg for 6 patients (1.6%). Moderate hypoxemia (SpO<sub>2</sub> < 95%) was observed in 109 patients (24.7%) and severe hypoxemia (SpO<sub>2</sub> < 90%) in 64 patients (14.5%).

Death was reported in 48 patients (11.9%).

#### Biological and therapeutic characteristics

More than half of the patients had thrombocytopenia 252 (52.1%).

In total, 32 (7.4%) patients were treated with corticosteroid (between 80 and 120 mg methylprednisolone by intravenous bolus daily for 10 days) during their hospitalization. Treatment with hydroxychloroquine (600 mg daily in 3 doses for 10 days) and Azithromycin (500 mg on the first day followed by 250 mg for the next 4 days) was initiated in 398 patients (90.9%) according to national guidelines. Mechanical ventilation with orotracheal intubation was performed in 7 patients, of whom 6 patients (85.7%) died.

#### Predictors of severe hypoxemia

Table 3 shows the results of univariate and multivariate analysis of predictive factors of severe hypoxemia. In univariate analysis, age over 65 years, diabetes, hypertension and a history of surgery were predictive factors with the occurrence of severe hypoxemia (Table 3).

In multivariate analysis, two factors were independently associated with severe hypoxemia. Compared with adolescents and young individuals under 24 years of age, individuals over 65 years of age had a significantly higher risk of severe hypoxemia (Adjusted Odds Ratio [AOR]: 8.24, 95% confidence interval [95% CI]: 2.83; 24.01). The risk of severe hypoxemia was significantly higher

in patients with a history of diabetes (AOR: 2.43; 95% CI: 1.17; 5.06) compared with those without diabetes.

#### Discussion

The objective of this study was to investigate the predictive factors of severe hypoxemia in patients treated during the first wave of the epidemic in Burkina Faso. The results obtained revealed, on the one hand, frequencies of 24.5% and 14.5% of moderate and severe hypoxia respectively, and on the other hand, that age over 65 years and diabetes were factors independently associated with the risk of presenting severe hypoxia. The frequency of severe hypoxia observed in our study is close to those commonly reported by the WHO (World Health Organisation, 2020). Studies conducted in Africa have shown variable frequencies on the subject. In particular in Democratic Republic of Congo and Morocco, frequencies of severe hypoxemia higher than 25% have been observed (El Aidaoui et al., 2020; Nachege et al., 2020). However, the epidemic seems to have less severe effects on the whole continent. Several hypotheses have been formulated concerning the hot climatic conditions unfavorable to the transmissibility of the virus, the under-diagnosis of the infection, and the demographic structure of the populations composed of people with few comorbidities (Ghosh et al., 2020; Martinez-Alvarez et al., 2020; Nguimkeu and Tadadjeu, 2021). The frequency we observed could be related to the more frequent need for hospitalization of people with respiratory symptoms or comorbidities. It seems logical to us to suggest a higher frequency of people who were ill at the beginning of this epidemic and did not receive a diagnosis because of a lack of diagnostic testing for SARS-Cov-2, due to the lack of hypoxia screening tools, including the pulse oximeter. This is a tool that was not routinely available in health centers.

The gender distribution shows a clear predominance of male patients. These same data are found in studies performed in socially and culturally similar environments (Tchole et al., 2020). In contrast, the data reported in a meta-analysis show an equitable distribution of patients by gender (Peckham et al., 2020). So far, the data described do not show a higher transmission for one gender than the other, but rather a higher mortality in men.

The frequency of hypoxemic patients with middle and high socio-economic levels is higher in the study population. This differs with data that predicted higher frequencies of SARS-Cov-2 infection and COVID-19 severity levels in patients living in low socioeconomic status (Patel et al., 2020b). Our findings probably reveal an under-diagnosis of COVID-19 and a lower utilization of care in populations with low socio-economic status. Burkina Faso in particular does not have a universal health insurance system, which contributes to lower attendance at health facilities. Besides, our study shows that there is no statistically significant difference in the frequency of severe hypoxemia between the different socio-economic levels. The frequency of respiratory severity was more prevalent in the socially disadvantaged population group. This study reinforces the need to improve access to diagnosis and detection tools for hypoxemia in low- and middle-income countries.

About 5% of hypoxic patients fall into a critical situation requiring mechanical ventilation (Wiersinga et al., 2020). In our study, orotracheal ventilation was performed on seven (7) patients for various reasons, including insufficient resuscitation materials and equipment in health facilities (less than 15 functional resuscitation beds throughout the country), deficiencies in the preparedness and organization of the resuscitation units to receive COVID-19 and non-COVID-19 patients at the same time, and late care-seeking by patients. The insufficiency of respiratory equipment and functional resuscitation units in low-resource countries

**Table 2**  
Clinical, biological and therapeutic characteristics of SARS-Cov-2 infected patients.

Features	Number	%
<b>History and co-morbidities</b>		
Chronic bronchopneumonia	20	4.5
History of severe acute respiratory disease*	17	3.8
History of cardiovascular diseases	77	17.4
Arterial Hypertension	97	21.9
Diabetes	55	12.4
Chronic hepatopathy	8	1.8
History of neuropsychiatric diseases	6	1.4
Systemic disease	5	1.1
Sickle cell disease	5	1.1
<b>Clinical signs</b>		
<i>Respiratory signs</i>		
Cough	186	42.1
Anosmia	16	3.6
Pharyngeal pain	2	0.5
Rhinorrhoea	74	16.7
Hemoptysis	4	0.9
Respiratory distress	12	2.7
Chest pain	4	0.9
<i>Extra respiratory signs</i>		
Altered state of consciousness (confusion, disorientation, Glasgow coma scale < 15)	10	2.3
Digestive signs	17	3.8
Diffuse allergies	91	20.6
Ageusia	10	2.3
Headache	74	16.7
Fever/chills	246	55.7
Other symptoms*	10	2.4
<b>Hemodynamic parameters (N = 370)</b>		
Systolic Blood Pressure ≤ 100 mmHg	31	8.5
Diastolic Blood Pressure ≤ 60 mmHg		1.6
SpO <sub>2</sub> < 90%	64	14.5
SpO <sub>2</sub> < 95%	109	24.7
<b>Biological parameters</b>		
C-reactive protein > 6 (N = 163)	52	32.0
Leukopenia < 4000/mm <sup>3</sup> (N = 251)	27	10.7
Haemoglobin level < 8 g/dl (N = 249)	8	3.2
Platelet count < 150 000/mm <sup>3</sup> (N = 250)	212	52.1
ASAT > 40 UI (N = 256)	16	6.3
ALAT > 40 UI (N = 259)	10	3.9
<b>Treatment (n = 434)</b>		
Injectable corticosteroids	32	7.4
Hydroxychloroquine	398	90.9
Azithromycin	399	91.1

has been noted by some authors (Mennechet and Dzomo, 2020). Yet, this is the cornerstone of COVID-19 treatment. In the treatment centers, an intensive care unit was not available and operational for the management of severe cases until May, and the maximum number of cases was notified between March 24 and April 24, as shown in Figure 2. Indeed, many health facilities did not have the equipment to monitor oxygen saturation. The Lancet Commission on Global Surgery revealed that about a quarter of hospitals surveyed in resource-limited countries did not have an adequate supply of oxygen (Meara et al., 2015). Even when this equipment is present, it is more often defective and does not provide the desired amount of oxygen (Dondorp et al., 2020). A common problem is the leakage of oxygen through poorly adapted connectors, which can lead to a wastage, loss of up to 70% of the oxygen contained in the O<sub>2</sub> cylinder (Bradley et al., 2014). This study highlights the strong need to equip healthcare facilities with respiratory and resuscitation equipment. Moreover, even when this equipment is available and functional, the probability of survival remains very low in critical cases (Huang et al., 2020).

Factors that influence the occurrence of hypoxia in our study are diabetes, hypertension, history of surgery and advanced age. Several studies reported the same factors as associated with hypoxic pneumonia, distress, admission to intensive care units and death (Dorjee et al., 2020; Tian et al., 2020).

We found that age over 65 years was a factor associated with severe Covid-19. These results are in agreement with the majority of studies that link age to severity and mortality of patients with Covid-19. The age is variable according to the studies (El Aidaoui et al., 2020). Being 80 years of age or older exposes to a higher risk of hypoxia and to a 14-fold higher risk of severe COVID-19 (Covino et al., 2020). The few existing data in Africa on the subject support the link between advanced age and the severity of the infection (Mennechet and Dzomo, 2020).

Age-related diseases, mainly diabetes and hypertension, also represent risk factors for severity in our study. Xie et al. showed in a Chinese study that age and hypertension were predictive factors for hypoxemia (Xie et al., 2020). Similar data have been found in other African countries. Diabetes and hypertension are diseases with increasing frequencies in our context (Glezeva et al., 2018; Nulu et al., 2016). Recent studies showed that the prevalence of diabetes and hypertension are 46% and 7.1% in Africa (Atun et al., 2017; Cappuccino and Miller, 2016). The pathophysiology of the association between the severity of COVID-19 and cardiovascular diseases and diabetes remains insufficiently understood. The hypothesis of an over-expression of the membrane angiotensin-2 converting enzyme by angiotensin-2 receptor blockers and angiotensin-2 receptor antagonists, enhancing cell invasion by CoV-2-SARS, remains hypothetical, is insufficient to explain the pathogenesis of this virus, and should not lead to the interruption of these treatments. These data should induce an intensification of the diagnosis of COVID-19 in any patient hospitalized for diabetes or hypertension, or in any patient presenting a decompensation of these conditions.

A history of surgery is a factor associated with Covid-19 in univariate analysis. Very few studies have linked history of surgery to severe hypoxemia. Molière et al. reported a risk of severe COVID-19 in the early postoperative periods (Molière and Veillon, 2020). Indeed, the risk of nosocomial contamination of COVID-19 is greater in the immediate postoperative periods. In addition, surgery, particularly heavy surgery, increases vulnerability due to undernutrition, invasive care and the risk of infection of the operating site, which could increase the severity of COVID-19. Our study did not allow us to specify the types of surgery or the delays of the surgery in relation to the COVID-19 episode. Nevertheless, this result deserves to be further investigated by other studies to find a link between COVID-19 withdrawal and the history of surgery.

Some limitations are to be pointed out in this study. This study used routine data, which does not allow us to provide an exhaustive description of the signs and the patients' history due to the missing data in the medical records. In addition, the patients included might be those who were at higher risk of respiratory complications, and that would have increased the prevalence of severe hypoxia observed. The assessment of hypoxia based on oxygen saturation monitored using the pulse oximeter may also be exposed to a potential information bias. In fact, this saturation is significantly different from the one measured on arterial blood with a variation of about 4% (Tobin et al., 2020). However, this study provided more information on clinical signs of COVID-19 in the context of resource-limited countries.

## Conclusion

This real-life study carried out in a resource-limited country showed that age over 65 years and diabetes were predictive factors of respiratory complications during COVID-19. The severity factors of Covid-19 are similar in African and Caucasian populations. The

**Table 3**

Predictors of severe hypoxemia in SARS-Cov-2 infected patients hospitalized at Tengandogo Teaching Hospital and Princess Sarah Clinic in Ouagadougou (Burkina Faso).

Variables	SpO <sub>2</sub> < 90%.N (%)	Crude odds ratio (IC95%)	p	Adjusted odds ratio (IC95%)	p
Sex					
- Female	25 (15.1)	1	0.78		
- Male	39 (14.1)	0.92 (0.53; 1.60)			
Age group (in years)					
[9–24]	5 (6.4)	1	<0.01	1	<0.01
[25–49]	12 (7.0)	1.09 (0.37; 3.22)		0.92 (0.31; 2.74)	
[50–64]	24 (19.0)	3.43 (1.25; 9.42)		2.53 (0.90; 7.14)	
Over 65 years old	23 (42.6)	10.82 (3.77; 31.08)		8.24 (2.83; 24.01)	
Socio-economic level					
Low	23 (13.8)	2.47 (0.55; 11.05)	0.33		
Intermediate	19 (10.0)	1.71 (0.38; 7.72)			
High	2 (6.1)	1			
Diabetes					
No	48 (12.4)	1	<0.01		<0.01
Yes	16 (29.1)	2.89 (1.50; 5.58)		2.43 (1.17; 5.06)	
Cardiovascular disease					
No	49 (13.4)	1	0.17		
Yes	15 (19.5)	1.56 (0.82; 2.95)			
Arterial hypertension					
No	40 (11.7)	1	<0.01		
Yes	24 (24.7)	2.49 (1.41; 4.39)			
History of chronic respiratory disease					
No	62 (14.8)	1	0.55		
Yes	2 (10.0)	0.64 (0.14; 2.82)			
Systemic disease					
No	63 (14.5)		0.72		
Yes	1 (20.0)	1.48 (0.16; 13.46)			
History of surgery					
No	61 (14.1)	1	0.03		
Yes	3 (50.0)	6.08 (1.20; 30.82)			

difference in severity and mortality frequencies may be related primarily to the demographic structure of the populations, which are younger in Africa and have fewer severity factors. These results should encourage the intensification of the screening of COVID-19 in any patient hospitalized for diabetes or hypertension, or in any patient with decompensation of these conditions, in order to ensure a good surveillance.

#### Authors' contributions

DEA, SKA, PGEA, DI, ZJ and KS designed the study, wrote the research protocol. DEA, SKA, OAR, DDL, CK, SA, MS, KM, ZS, KRP, HU, BH, BRA, ZN, KF, AS collected and analyzed the data, and wrote the manuscript. DEA, SKA, DDL, DI, ZJ provided the bibliography. DEA, SKA, DI, PGEA, AS, KS and LLC directed the study, gave a critical reading and final correction of the article. All authors read and approved the final manuscript.

#### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

#### Competing interests

The authors declare that they have no competing interests.

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- Department of biomedical and public health, Research Institute of Health Sciences. Ouagadougou (Burkina Faso)

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