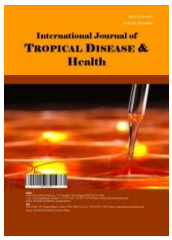

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COVID-19 and Comorbidities in Douala, Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) still negatively impacting the world. This study aimed at determining the prevalence of COVID-19 and comorbidities, associated factors, and evaluating the impact of these comorbidities on COVID-19 patients.
Study Design: Cross-sectional hospital-based study.
Place and Duration of Study: From January to March 2022, the present study was conducted at four health facilities in Douala town (Littoral Region, Cameroon).
Methodology: Anthropometric, bioimpedance, physiological, blood and nasopharyngeal samples were used for diagnosing COVID-19, hepatitis B virus, diabetes, obesity and hypertension. SARS-CoV-2 genome were detected by retrotranscriptase quantitative polymerase chain reaction. Data were analyzed with StatView v5 and GraphPad v5.03 software, and statistical significance was set at $p < 0.05$.
Results: A total of 178 patients, 139 Cameroonian and 39 foreigners, were finally included in the study. Lower COVID-19 vaccination coverage was seen in Cameroonians compared to foreigners

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(25.2% vs 43.6%, *P* = .02). No COVID-19 infection cases were found. The overall prevalence of diabetes, hypertension, obesity and HBV was 11.2%, 17.9%, 28.1% and 36.5%, respectively. Nearly 35% of patients were diagnosed with at least two of these comorbidities that significantly impacted on anthropometric, bioimpedance and physiological parameters. The risk of past COVID-infection was increased by 1.06 (95%CI 1.00 – 1.10, *P* = .03) and 2.81 (95%CI 1.65 – 5.77, *P* = .04) with one-unit increase in age and BMI, respectively. In contrast, risk of past COVID-19 infection was decreased by 94% (AOR = 0.06, 95%CI 0.01 – 0.76, *P* = .03) in foreigners compared to Cameroonians.

Conclusion: This study outlines the importance to manage comorbidities in context of COVID-19 in Cameroon. Further studies should be conducted with more documented investigations about their epidemiology and impact on the natural history of COVID-19 in the country.

Keywords: COVID-19; comorbidities; prevalence; interaction; Cameroon.

ABBREVIATIONS

95%CI : Confidence Interval at 95%
ANOVA : Analysis of Variance
AOR : Adjusted Odds Ratio
BDH : Bangé District Hospital
BMI : Body Mass Index
BoDH : Bonassama District Hospital
COR : Crude Odds Ratio
COVID-19 : Coronavirus Disease 2019
DBP : Diastolic Blood Pressure
DDH : Deido District Hospital
HbA1c : Glycated Hemoglobin
HBV : Hepatitis B Virus
NDH : Nylon District Hospital
RT-qPCR : Retrotranscriptase Quantitative Polymerase Chain Reaction
SARS-CoV-2 : Severe Acute Respiratory Syndrome Coronavirus 2
SBP : Systolic Blood Pressure
SD : Standard Deviation
sSA : Sub-Saharan Africa

1. INTRODUCTION

Since the first case of novel coronavirus disease 2019 (COVID-19) reported in China, the disease has spread incredibly fast to other regions of the world, and has become a pandemic within a few weeks [1]. COVID-19 is caused by a virus called severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) which belongs to Coronaviridae family [2]. More than 200 countries are still hit by the COVID-19 at varying levels; the disease is declining in some countries while increasing or rebounding in others. The latest statistics indicate that COVID-19 disproportionally affects the different parts of the globe, with highest morbidity and mortality rates seen in the Americas and Europe while lowest burden is seen in areas including sub-Saharan Africa (sSA) countries. In Cameroon, COVID-19 was responsible for ~120000 cases and ~2000 deaths since the onset of the pandemics (https://coronavirus.jhu.edu/map.html), and available data indicate a high circulation of SARS-CoV-2 in several towns of the country.

Natural history of COVID-19 is complex, diverse and shaped by a cocktail of factors related to human host, virus and environment, with a clinical spectrum ranging from asymptomatic carriage to potentially deadly severe complications [3]. Along with the pulmonary effects of COVID-19, several reports have indicated multiorgan involvement such as gastrointestinal, cardiovascular, and neurologic manifestations in COVID-19 patients [3]. A large number of risk factors are associated with viral shedding, severe complications and death. These factors include mainly advanced age and comorbidities such as diabetes, obesity and cardiovascular disorders [4–7].

Even though reports point out the increasing burden of the above mentioned comorbidities in sSA countries, very few studies on COVID-19, associated factors, and the role of these comorbidities have been conducted in the continent, especially in Cameroon [8–11]. Diabetes and hepatitis B virus (HBV) infection are increasingly documented at significant rates in African populations, and few studies outlined increased risk of COVID-19 related complications and death in African patients suffering from diabetes and chronic HBV infection [9,12,13]. Here, we determined the prevalence of COVID-19 and comorbidities (obesity, diabetes, HBV and hypertension), identified associated factors, and evaluated the impact of these comorbidities in COVID-19 patients attending health facilities in the town of Douala, Cameroon.

2. MATERIALS AND METHODS

2.1 Study Design

This was a hospital-based prospective cross sectional study carried out in the town of Douala, Littoral region, Cameroon. Convenient sampling was used to recruit participants attending the Clinical Biology laboratory of the hospitals, and thereafter aims and objectives of the study were explained to each patient. Structured questionnaire form was administered to each included participant to document sociodemographic and clinical information. Anthropometric (weight, height, muscle mass, body and visceral adipose tissues, water content) and physiological (systolic and diastolic blood pressures) measurements were made for each participant while blood and nasopharyngeal sample collection was performed for glycaemia, HBV and COVID-19 screening.

2.2 Study Sites

From January to March 2022, this study was conducted at four health facilities of Douala town (Littoral Region, Cameroon) namely Nylon district hospital (NDH), Deido district hospital (DDH), Bangé district hospital (BDH), and Bonassama district hospital (BoDH). These hospitals receive a high frequency of patients coming for different health reasons, and this guided the choice of these hospitals as study sites.

2.3 Study Population

Participants included in the study were of both sexes, aged > 18 years old, coming for COVID-19 test, having a COVID-19 infection history, and willing to participate in the study by signing the informed consent form. Conversely, patients having declined to participate and those in whom the blood collection was impossible were excluded from the study.

2.4 Data Collection

A structured questionnaire form was used to document participants' characteristics through individual 10-15 minute interviews. The first section of the questionnaire captured sociodemographic information viz. age, nationality, educational level, residence area, marital status and occupation. Anthropometric (weight, height, body mass index – BMI) and impedance (muscle mass, body and visceral adipose tissues & water) data were captured in the second part of the questionnaire. The third part was focused on past and current comorbidities such hypertension, diabetes, respiratory and cardiovascular disorders, and infections such as malaria, human immunodeficiency virus and HBV. The last two parts captured information on the COVID-19 infection history and COVID-19 vaccination & treatment. Thereafter, blood and nasopharyngeal samples were collected and transported to the Clinical Virology department of Douala Laquintinie hospital for HBV and COVID-19 tests.

2.5 Anthropometric Parameters

Weight (W) and height (H) were measured using a digital scale and standard measuring tape, respectively. These two parameters were used to compute BMI (Kg/m^2) using the Quetelet's formula: $BMI = W/H^2$. Bioelectrical impedance parameters (lean body mass, bone mass, water content, body fat and visceral adipose tissue) were measured using a smart wireless body fat scale coupled with an Android 11.1.1 smartphone. Each patient took off their shoes and climbed on the scale which thereafter send a low intensity and frequency electrical impulses (10-100 KHz) through the body in order to measure the resistance/impedance of tissues. The results were transferred to the smartphone for analysis using the New Iwellness application version 3.0.

2.6 Physiological Parameters

Systolic and diastolic blood pressures (SBP and DBP) were measured three times in patients with no history of hypertension and the arithmetic mean of SBP/DBP readings was used as final result. SBP and DBP were measured once in those with documented hypertension. Diagnostic of pre-hypertension and hypertension was performed by cardiologists of the health facilities. Fasting glycaemia was further measured twice for patients with hyperglycemia, the two measurements were two-week spaced. If hyperglycemia was still detected, glycated hemoglobin (HbA1c) was determined to diagnose diabetes as per standard methods.

2.7 Diabetes, HBV and COVID-19 Status

Glycaemia was determined based on fresh whole blood analysis using a rapid blood glucose meter (ViVaCheck^{TM} Ino Biotech, Hangzhou, China). Blood samples were collected by venipuncture

using sterile syringes and then stored at -4°C in a fridge, 16 hours on average, until laboratory procedures. Blood samples were centrifuged (CWS 4236 A centrifuge) at 3000 rpm for 10 minutes and thereafter aliquoted in Eppendorf tubes. The sera were stored at -20°C until diagnosis of HBV infection is performed. Diagnosis of HBV was based on the detection of HBV antigens using the ELISA test (URIT-660 microplate reader, URIT Medical Electronics, Co, Ltd, Guangxi, China). The results were expressed as valid (negative and positive) or invalid. Nasopharyngeal swabs were used for detecting SARS-CoV-2 infections among patients. Viral genome was detected by retrotranscriptase quantitative polymerase chain reaction (RT-qPCR) analysis of the *ORF1a* and *N* genes using a QuantStudio™ 7 real time thermocycler (Applied Biosystems, Massachusetts, USA). Cycle threshold (Ct) value of RT-qPCR was used to determine SARS-CoV-2 viremia.

2.8 Operational Definitions

- Based on BMI analysis, patients were categorized as underweight (<18.5 Kg/m^2), normal (18.5 – 24.9 Kg/m^2), overweight (25.0 – 29.9 Kg/m^2), obese (30.0 – 34.9 Kg/m^2), and morbid obese (≥ 35 Kg/m^2) [14].
- Patients were grouped as positive, negative and doubtful based on the test result for HBV infection.
- Normotensive patients were those with SBP <120 mmHg and/or DBP <80 mmHg with no antihypertensive medication taking. Pre-hypertension was defined as SBP of 120–139 mmHg and/or DBP of 80–89 mmHg. Grade 1 hypertension was defined as SBP of 140–159 mmHg and/or DBP of 90–99 mmHg while grade 2 or 3 hypertension was defined as SBP ≥160 mmHg and/or DBP ≥100 mmHg and/or use of antihypertensive medication in the past two weeks [15].
- Fasting and post-prandial hyperglycemia were defined as blood glucose levels ≥ 1.26 g/dL and ≥ 2 g/dL, respectively.
- Diabetes was defined as HbA1c ≥ 6.5%. The diagnostic of diabetes was made by endocrinology specialists of health facilities included in the study.
- Patients with a Ct value < 37 for RT-qPCR was considered negative for COVID-19 infection.

2.9 Ethical Statements

This study was carried out as per the guidelines for human experimental models in clinical research as stated by the Cameroon Ministry of Public Health. Ethical and administrative clearances were issued by the ethics committees of the University of Douala (Identification number: 2924 CEI-UDo/10/2021/M), Littoral health regional delegation (Identification number: 1328/AAR/MINSANTE/DRSPL/BCASS), and Douala Laquintinie Hospital (Identification number: 06713/AR/MINSANTE/DHL). The aim and objectives of the study were explained to participants in the language they understood best (French or English), and their questions were answered. Only patients who signed an informed consent form for their participation were enrolled. Participation in the study was strictly voluntary and patients were free to decline answering any question or totally withdraw if they so wished at any time.

2.10 Statistical Analysis

Data were keyed into an Excel spreadsheet, coded, verified for consistency and then analyzed with StatView v5.0 (SAS Institute, Chicago, Inc., Illinois, USA) and GraphPad v5.03 (GraphPad PRISM, San Diego, Inc., California, USA) software. Categorical and continuous variables were summarized as frequency, percentages with 95% confidence intervals (95%CI) and mean ± standard deviation (SD). Pearson's chi square and Fisher's exact tests were used to compare proportions while Student, one-way analysis of variance ((ANOVA), Mann-Whitney, and Kruskal-Wallis tests were used to compare mean values between groups. Pairwise comparisons between groups were performed using post hoc Duncan's test. Univariate and multivariate logistic regression analyses were used to identify determinants of COVID-19 infection. Quantification of COVID-19 infection risk was made by computing crude and adjusted odds ratio (COR and AOR) and their 95%CIs. A *p*-value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Selection of the Participants Included in the Study

Two hundred and seventy-three patients were approached in the different hospitals, and upon exclusion criteria 178 were finally included in the study (Fig. 1).

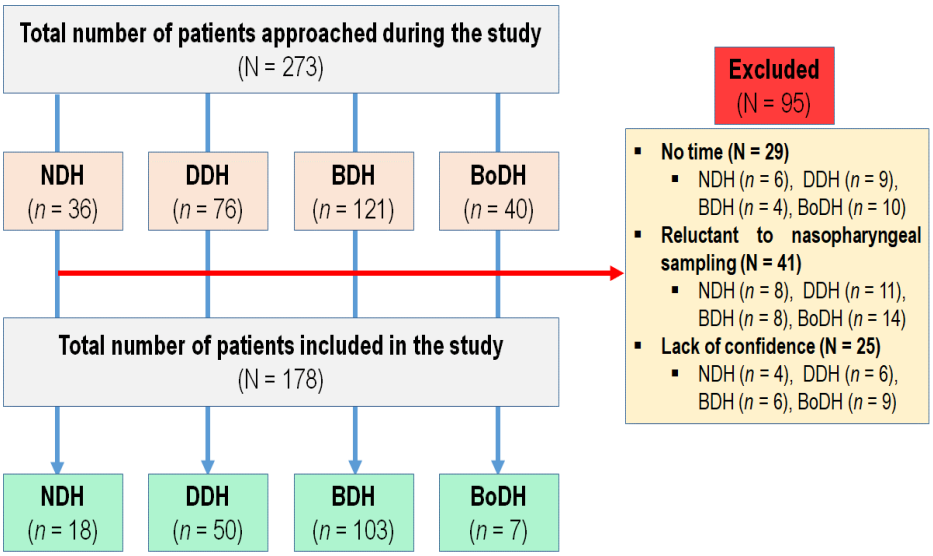


Fig. 1. Flow diagram depicting inclusion of patients

BDH: Bangue district hospital, BoDH: Bonassama district hospital, DDH: Deido district hospital, NDH: Nylon district hospital

Table 1. Distribution of the included participants by gender, age, and COVID-19 history & vaccination

	Total (N = 178)		Cameroonian (*n* = 139)		Foreigners (*n* = 39)		
Variables	**n**	**%**	**n**	**%**	**n**	**%**	**P#**
Gender							
Female	69	38.8	58	41.7	11	28.2	.14
Male	109	61.2	81	58.3	28	71.8	
Age (years)							
[21 - 30[	70	39.3	40	28.8	30	76.9	< .0001*
[30 - 40[	42	23.6	39	28.1	3	7.7	
[40 - 50[	29	16.3	27	19.4	2	5.1	
[50 - 60[	19	10.7	17	12.2	2	5.1	
[60 - 70[	11	6.2	10	7.2	1	2.6	
≥ 70	7	3.9	6	4.3	1	2.6	
History of COVID-19 infection?							
No	152	85.4	114	82.0	38	97.4	.01*
Yes	26	14.6	25	18.0	1	2.6	
Period of positive COVID-19 result							
1 month	3	11.5	3	12.3	0	0.0	.57
2 month	8	30.8	8	32.0	0	0.0	
3 month	9	34.6	8	32.0	1	100.0	
4 month	6	23.1	6	24.0	0	0.0	
COVID-19 vaccination?							
No	126	70.8	104	74.8	22	56.4	.02*
Yes	52	29.2	35	25.2	17	43.6	
HBV vaccination?							
No	168	94.4	131	94.2	37	94.9	.88
Yes	10	5.6	8	5.8	2	5.1	
COVID-19 vaccine							
None	126	70.8	104	74.8	22	56.4	.03*
AstraZeneca	7	3.9	7	5.0	0	0.0	

	Total (N = 178)		Cameroonian (*n* = 139)		Foreigners (*n* = 39)		
Variables	**n**	**%**	**n**	**%**	**n**	**%**	**P[#]**
Johnson & Johnson	11	6.2	7	5.0	4	10.3	
Pfizer	20	11.2	13	9.4	7	17.9	
Sinopharm	14	7.9	8	5.8	6	15.4	

Data are expressed as frequency (n) and percentage (%) ; COVID-19: Coronavirus disease 2019, HBV: Viral hepatitis B; [#]Pearson chi square and Fisher's exact tests were used to compare the groups; [*]Statistically significant at P < .05

3.2 Characteristics of the Participants

Of the 178 participants included in the study, 139 were Cameroonian and 39 were foreigners. The stratification of patients by ethnicity revealed statistically significant differences between Cameroonians and foreigners for age, COVID-19 infection history and vaccination (Table 1). Foreigners were younger than Cameroonians with mean age ± SD of 29.7 ± 11.5 years and 39.5 ± 13.3 (*P* < .0001), respectively. Also, 80% of foreigners were aged 21 – 30 years. The proportion of patients with a history of COVID-19 infection was higher in Cameroonians (18%) compared to foreigners (2.6%). In contrast, lower COVID-19 vaccination coverage was seen in Cameroonians compared to foreigners (25.2% vs 43.6%, *P* = .02) (Table 1).

Likewise seen in Table 1, there were statistically significant differences between Cameroonian and foreigners for BMI (Kg/m^2), glycaemia (g/dL), fatty mass (Kg), visceral adipose tissue (Kg) and water content (%) (Table 2). The first four parameters were significantly higher in Cameroonians compared to foreigners (e.g., 26.8 ± 4.4 vs 22.1 ± 4.1for BMI, *P* < .0001). Water content (%) was on average lower in foreigners compared to their Cameroonian counterparts (53.11 ± 6.88 vs 47.91 ± 6.47, *P* < .0001).

3.3 Prevalence of HBV, Diabetes, Obesity, Hypertension and COVID-19

On analysis, diabetes, hypertension, obesity and HBV were most frequently reported among the patients. The overall prevalence of diabetes, hypertension, obesity and HBV infection was 11.2%, 17.9%, 28.1% and 36.5%, respectively. Using RT-qPCR, no COVID-19 infection cases were found in this study. Noted that 35% (7/20) and 58% (29/50) of patients with diabetes and hypertension were living with these diseases before their inclusion in the study. Thus, the prevalence of new cases for diabetes and hypertension was 7.3% (13/178, 95%CI 4.3 – 12.1%) and 11.8% (21/178, 95%CI 7.9 – 17.4%), respectively. Of the 117 patients diagnosed with at least one of the above mentioned diseases, 31 (26.5%) had two diseases (Table 3). In Fig. 2A, prevalence of obesity was significantly higher in Cameroonians compared to foreigners (21.6% vs 5.1%, *P* < .0001).

Table 2. Anthropometric, physiological and bioimpedance details of the participants

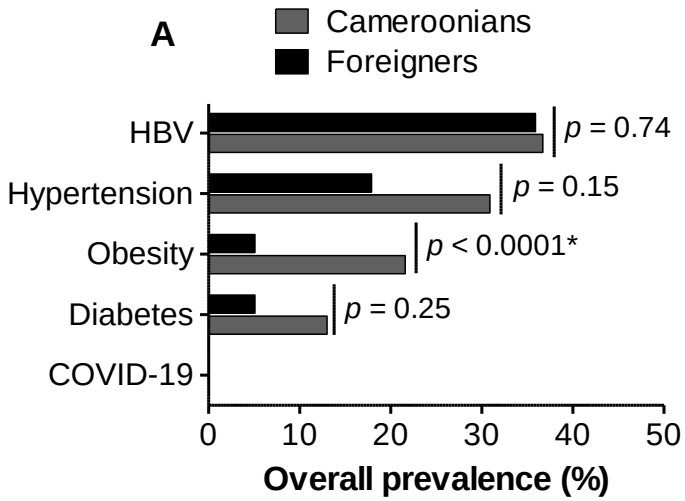
Parameters	**Total (N = 178)**	**Cameroonian (*n* = 139)**	**Foreigners (*n* = 39)**	***P*[#]**
BMI (Kg/m^2)	25.8 ± 4.7	26.8 ± 4.4	22.1 ± 4.1	< .0001*
Glycaemia (g/dL)	0.96 ± 0.28	0.99 ± 0.29	0.88 ± 0.21	.04*
SBP (mmHg)	123 ± 19	123 ± 18	123 ± 19	.98
DBP (mmHg)	76 ± 12	77 ± 13	77 ± 11	.91
Lean body mass (Kg)	48.9 ± 8.4	48.92 ± 9.77	48.89 ± 7.05	.98
Fatty mass (Kg)	27.5 ± 12.0	29.98 ± 10.83	18.65 ± 12.06	< .0001*
Water content (%)	49.1 ± 6.9	47.91 ± 6.47	53.11 ± 6.88	< .0001*
Bone mass (Kg)	2.70 ± 0.30	2.71 ± 0.33	2.59 ± 0.32	.06
Visceral adipose tissue (Kg)	9.80 ± 4.70	10.51 ± 4.89	7.21 ± 2.67	< .0001*

Data are expressed as mean ± standard deviation (SD); BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure; [#]Unpaired t-test was used to compare the groups; [*]Statistically significant at P < .05

Table 3. Patterns of diseases seen in study participants

Diseases	*n*	%	95%CI
Overall prevalence[a]			
COVID-19	0	0.0	-
Diabetes	20	11.2	7.4 – 16.7
Obesity	32	17.9	13.0 – 24.3
Hypertension	50	28.1	22.0 – 35.1
HBV	65	36.5	29.8 – 43.8
Prevalence of diseases' association[b]			
COVID-19	0	0.0	-
Diabetes	9	5.1	2.5 – 9.3
Obesity	11	6.2	3.5 – 10.7
Hypertension	18	10.2	6.5 – 15.4
HBV	39	21.9	16.5 – 28.5
Diabetes + HBV	1	0.5	0.1 – 3.1
Diabetes + Obesity	2	1.1	0.3 – 4.0
Diabetes + Hypertension	4	2.2	0.8 – 5.6
Obesity + HBV	5	2.8	1.2 – 6.4
Hypertension + Obesity	7	3.9	1.9 – 7.9
Hypertension + HBV	12	6.7	3.9 – 11.4
Diabetes + Hypertension + Obesity	1	0.5	0.1 – 3.1
Diabetes + Hypertension + HBV	2	1.1	0.3 – 4.0
Hypertension + Obesity + HBV	5	2.8	1.2 – 6.4
Diabetes + Hypertension + Obesity + HBV	1	0.5	0.1 – 3.1
Total number of infection type[c]	117	65.7	58.5 – 72.3

Data are expressed as frequency (n) and percentage (%); COVID-19: Coronavirus disease 2019, HBV: Viral hepatitis B, 95%CI: Confidence interval; [a]Prevalence of each disease regardless status their status one another; [b]Prevalence of each disease either alone or in association; [c]Determined by summing up the frequency and percentage presented in "b"



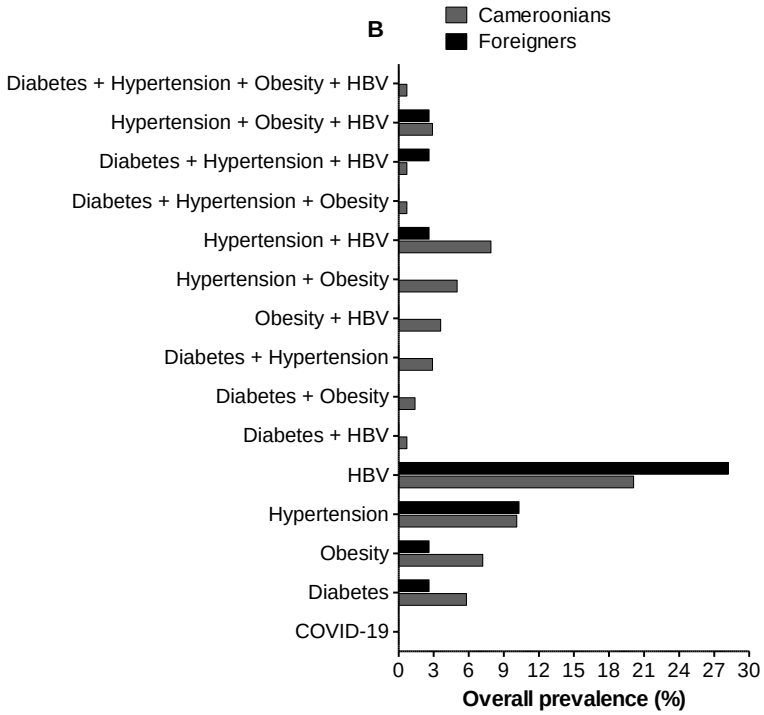


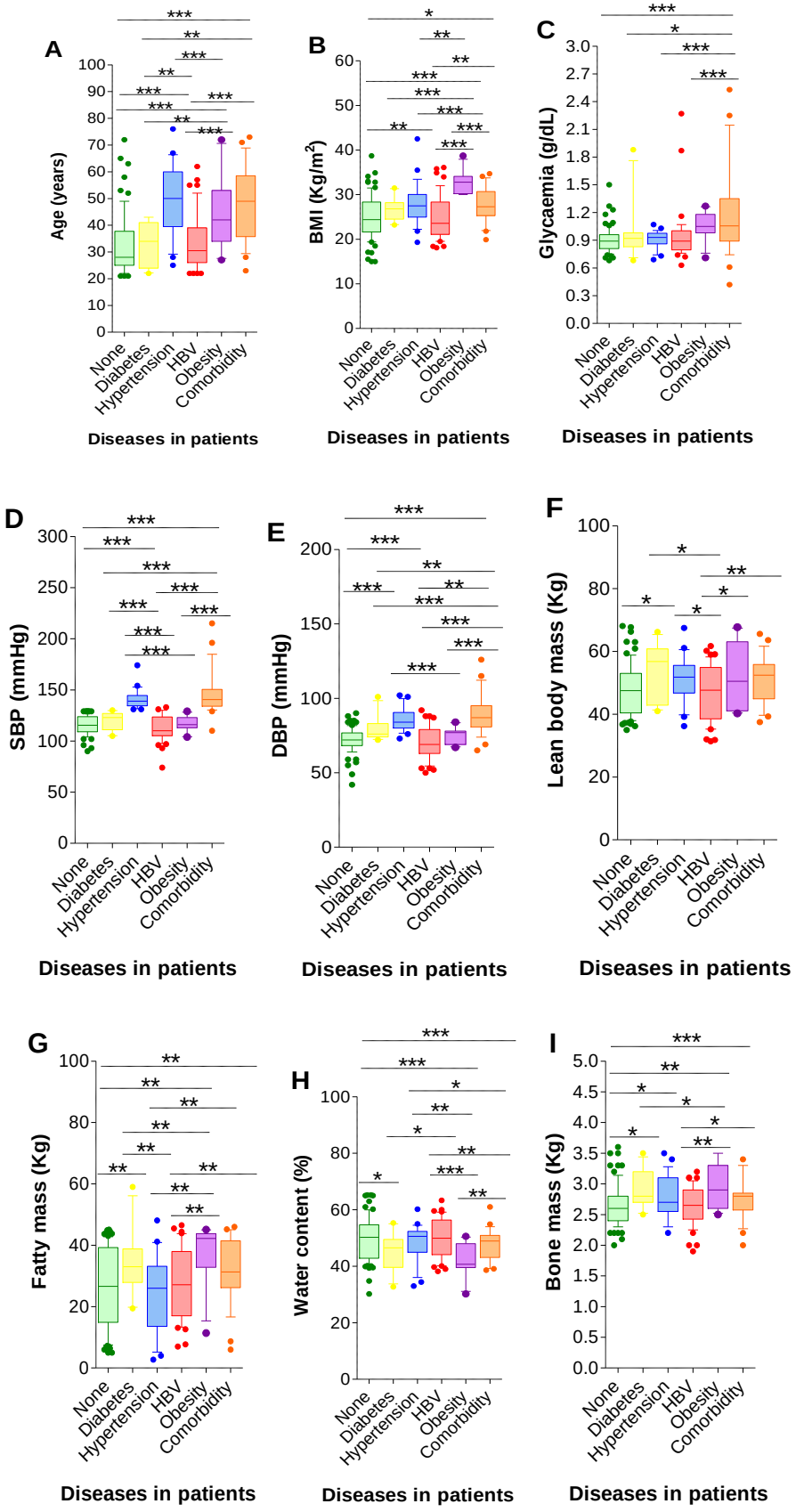
Fig. 2. Prevalence of comorbidities (A) and nature of the association (B) by ethnicity

*Each bar represents percentage (%); COVID-19: Coronavirus disease 2019, HBV: Viral hepatitis B; #Pearson chi square and Fisher's exact tests were used to compare the groups; *Statistically significant at P < .05*

Table 4. Association of hepatitis B virus, hypertension and diabetes comorbidities with respect to patients' characteristics

		HBV			Hypertension			Diabetes		
Variables	**N**	**n**	**%**	**P**	**n**	**%**	**P**	**n**	**%**	**P**
Ethnicity										
Cameroonian	139	51	36.7	.74	43	30.9	.15	12	8.6	.25
Foreigner	39	14	35.9		7	17.9		2	5.1	
Gender										
Female	69	24	34.8	.88	16	23.2	.49	8	11.6	.04*
Male	109	41	37.6		34	31.2		6	5.5	
Age (years)										
[21 - 30[	70	22	31.4	.15	4	5.7	< .0001*	1	1.4	.07
[30 - 40[	42	20	47.6		9	21.4		5	11.9	
[40 - 50[	29	9	31.0		11	37.9		2	6.9	
[50 - 60[	19	8	42.1		12	63.2		2	10.5	
[60 - 70[	11	3	27.3		8	72.7		1	9.1	
≥ 70	7	3	42.9		6	85.7		3	42.9	
COVID-19 history										
No	152	53	34.9	.001*	44	28.9	.01*	14	9.2	.33
Yes	26	12	46.2		6	23.1		0	0.0	
BMI										
Underweight	8	3	37.5	.77	0	0.0	.008*	0	0.0	.46
Normal	70	29	41.4		11	15.7		3	4.3	
Overweight	68	22	32.4		25	36.8		9	13.2	
Obese	32	11	34.4		14	43.8		2	6.3	

*Data are expressed as frequency (n) and percentage (%); COVID-19: Coronavirus disease 2019, HBV: Hepatitis B virus; #Pearson chi square and Fisher's exact tests were used to compare the groups; *Statistically significant at P < .05*


A
Age (years)
B
BMI (Kg/m²)
C
Glycaemia (g/dL)
D
SBP (mmHg)
E
DBP (mmHg)
F
Lean body mass (Kg)
G
Fatty mass (Kg)
H
Water content (%)
I
Bone mass (Kg)
None
Diabetes
Hypertension
HBV
Obesity
Comorbidity
Diseases in patients

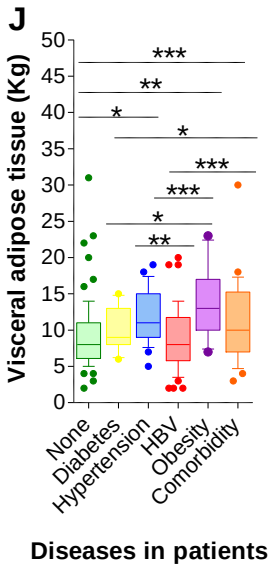


Fig. 3. Age (A), BMI (B), glycaemia (C), SBP (D), DBP (E), lean body mass (F), fatty mass (G), water content (H), bone mass (I) and visceral adipose tissue (J) by type of morbidity

BMI: Body mass index, DBP: Diastolic blood pressure, SBP: Systolic blood pressure
Comorbidity group consisted of patients with at least two comorbidities seen in the study
One-way ANOVA and Duncan's post hoc tests were used to make pairwise comparisons
Only statistically significant pairwise differences were plotted on the graphs
*Statistically significant at *P < .05, **P < .01, ***P < .001*

3.4 Prevalence of HBV, Hypertension and Diabetes by Patients' Details

In Table 4, prevalence rates of HBV, hypertension and diabetes stratified by patients' characteristics are presented. The prevalence of HBV was significantly higher in patients with COVID-19 history compared to those without any past COVID-19 infection (46.2% vs 34.9%, *P* = .001). Hypertension burden gradually increased with age, and highest proportion was seen in those aged ≥70 years old (85.7%). Similarly, overweight and obese patients were most affected by hypertension with prevalence of 36.8% and 46.8%, respectively. The prevalence of diabetes was significantly higher in females compared to males (11.6% vs 5.5%, *P* = .04).

3.5 Mean Variation of Age, Anthropometric, Physiological and Bioimpedance Parameters by Comorbidity Status

The influence of health status on age, anthropometric, physiological and bioimpedance are depicted in Fig. 3A-J. Patients suffering from hypertension only were significantly older (Mean = 48.8 years old) and had higher BMI (Mean = 27.9 Kg/m^2) compared to those without disease and those with diabetes only or HBV only (Fig. 3A & 3B). Glycaemia was higher in those diagnosed with at least two diseases, with a mean value of 1.21 g/dL (Fig. 3C). SBP and DBP values were significantly highest in patients with either hypertension alone or in association with other diseases (i.e., diabetes, HBV) (Fig. 2D & 2E). Fatty mass, bone mass and visceral adipose tissue values were highest in obese patients (Fig. 3F-J).

3.6 Impact of Ethnicity and Morbidity Status on Anthropometric, Physiological and Bioimpedance Parameters

As presented in Table 5, Cameroonian patients diagnosed with hypertension only were significantly older and had higher BMI than those diagnosed with other diseases (i.e., diabetes, HBV, and comorbidities). Regarding foreigners, those with comorbidities were significantly older than their counterparts with other diseases. Both in Cameroonian and foreigners, SBP and DBP were significantly higher in patients with comorbidities: 139.2 ± 20.6 mmHg (Cameroonians) and 167.3 ± 41.6 mmHg (foreigners) for SBP, 85.2 ± 13.5 mmHg and 95.3 ± 26.6 mmHg for DBP (Table 5). Lean body

mass was higher in comorbidity group compared to HBV only among Cameroonians while this parameter was higher in patients with comorbidities compared to those with no disease among foreigners.

When comparing Cameroonian and foreigners by stratifying results for type of disease, we have noted that HBV-infected Cameroonians were significantly older, had higher BMI and fatty mass than HBV-infected foreigners (35.2 ± 10.4 vs 25.3 ± 1.7, *P* = .001 for age, 24.5 ± 3.3 vs 20.9 ± 1.8, *P* = .001 for BMI, 28.8 ± 10.6 and 17.7 ± 6.1, *P* = .0007 for fatty mass). In contrast, mean DBP values were significantly lower in HBV-infected foreigners compared to HBV-infected Cameroonians (68.6 ± 10.5 vs 75.7 ± 10.2, *P* = .03). In hypertension group, only fatty mass and visceral adipose tissue were found to be significantly higher in Cameroonian compared to foreigners (25.4 ± 10.6 vs 10.2 ± 4.6, *P* = .00054 for fatty mass, 11.79 ± 3.09 vs 7.50 ± 1.91, *P* = .009 for visceral adipose tissue). In comorbidity group, no difference was found between Cameroonian and foreigners for all parameters analyzed.

3.7 Determinants of Past COVID-19 Infection

Univariate and multivariate logistic regression analyses were performed to identify factors associated with COVID-19 infection history. On multivariate analysis, three factors were identified namely ethnicity, patient's age and BMI (Table 6). The odds of past COVID-infection were increased by 1.06 (95%CI 1.00 – 1.10, *P* = .03) and 2.81 (95%CI 1.65 – 5.77, *P* = .04) with one-unit increase in age and BMI, respectively. In contrast, risk of past COVID-19 infection was decreased by 94% (AOR = 0.06, 95%CI 0.01 – 0.76, *P* = .03) in foreigners compared to Cameroonians (Table 6).

4. DISCUSSION

COVID-19 pandemics has caused high mortality and changed drastically habits of populations all over the world. In this study, we interested in the prevalence and relation between COVID-19 infection and concurrent diseases (i.e., diabetes, hypertension, HBV and obesity). To our knowledge, it is the first study in Cameroon that address this aspect which fits research priorities identified in the country [16].

Interesting, COVID-19 vaccine coverage was low in Cameroonian patients. This finding is likely related to beliefs of Cameroonian about deleterious effects of vaccines including COVID-19 vaccines. This has likely played a great role in increasing rates of psychological disorders such as depression and anxiety among African populations [17,18]. High rates of COVID-19 vaccine hesitancy was also found in South East Asia [19]. Even though the individual is willing to get vaccine against COVID-19, lack of financial constraints is also particular important in resources-limited countries such as Cameroon [20].

In this study, no COVID-19 infection cases were identified. This is not in line with a nationwide study that reported COVID-19 prevalence of ~11.8% - 32.0% across the ten regions of Cameroon [21]. We conducted this study in Douala that has been classified as a high risk area for COVID-19 infection based on the distribution of its risk factors (e.g., cardiovascular diseases, cancer, human immunodeficiency virus infection) [22]. Since 2019, countries faced several COVID-19 waves due to the emergence and spread of SARS-CoV-2 variants [23]. Currently, increasing COVID-19 infections are mainly seen in Europe and Americas, and very few cases are found in sSA countries such as Cameroon (https://coronavirus.jhu.edu/map.html).
Implementation and scale up of COVID-19 control measures including lockdown, vaccines, social distancing and masks have greatly participated in the reduction of COVID-19 burden. During intense COVID-19 transmission periods, these control measures, especially wearing masks and social distancing were highly used by Cameroonian populations [24]. Currently, such measures are no longer largely used in the country especially in armed conflict areas and less than 5% of the populations are vaccinated against the disease [25,26]. Thus, other factors such as self-medication with drugs and traditional medicines could explain the low rates of COVID-19 infection [27].

A high proportion (36.5%) of patients were positive for HBV antigens. Based on ethnicity, the HBV seroprevalence was 36.7% in Cameroonians. Noted that more than 90% of patients were not vaccinated against HBV infection, and this is consistent with a study conducted in Bamenda and Dschang, Northwest and Western regions of Cameroon [28,29]. Thus, the absence of HBV vaccine coverage could explain this high seroprevalence rate found here. This value is much higher than that reported in a

Table 5. Influence of ethnicity and comorbidity status on parameters of the participants

Variables	Ethnicity	None	Comorbidity	Diabetes	Hypertension	Obesity	HBV
Age (years)	Cameroonian	32.5 ± 9.4^{ac}	47.2 ± 13.5^{b}	32.0 ± 8.1^{c}	47.3 ± 13.8^{b}	47.1 ± 14.0^{b}	35.2 ± 10.4^{ac}
	Foreigners	25.3 ± 6.2^{ac}	52.3 ± 12.5^{b}	38.0 ± 0.0^{abc}	44.7 ± 16.4^{b}	30.0 ± 0.0^{abc}	25.3 ± 1.7^{c}
	$P^{\#}$	**.0006***	.55	n.a	.51	n.a	**.001***
BMI (Kg/m^2)	Cameroonian	24.7 ± 3.3^{a}	29.8 ± 4.6^{b}	25.9 ± 1.9^{a}	26.3 ± 2.2^{a}	32.6 ± 2.7^{c}	24.5 ± 3.3^{a}
	Foreigners	21.3 ± 4.3^{a}	26.9 ± 5.2^{b}	26.6 ± 0.0^{abc}	24.4 ± 4.4^{abc}	32.8 ± 0.0^{abc}	20.9 ± 1.8^{ac}
	$P^{\#}$	**< .0001***	.77	n.a	.09	n.a	**.0014***
Glycaemia (g/dL)	Cameroonian	0.90 ± 0.12^{a}	1.12 ± 0.40^{b}	0.88 ± 0.89^{a}	0.89 ± 0.07^{a}	1.04 ± 0.16^{ab}	1.00 ± 0.33^{ab}
	Foreigners	0.83 ± 0.09^{a}	1.12 ± 0.20^{b}	1.88 ± 0.00^{abc}	0.89 ± 0.10^{c}	1.05 ± 0.00^{abc}	0.83 ± 0.09^{c}
	$P^{\#}$	**.003***	.76	n.a	.73	n.a	.09
SBP (mmHg)	Cameroonian	114.9 ± 10.4^{a}	139.2 ± 20.6^{b}	117.9 ± 9.2^{a}	139.1 ± 8.4^{b}	117.0 ± 8.3^{a}	110.8 ± 12.9^{a}
	Foreigners	116.7 ± 7.6^{a}	167.3 ± 41.6^{b}	126.0 ± 0.0^{abc}	139.0 ± 2.9^{c}	116.0 ± 0.0^{abc}	117.5 ± 10.4^{a}
	$P^{\#}$	.55	.11	n.a	.69	n.a	.11
DBP (mmHg)	Cameroonian	70.6 ± 9.4^{ac}	85.2 ± 13.5^{b}	77.3 ± 5.4^{ab}	85.6 ± 8.9^{b}	75.20 ± 5.8^{ac}	68.6 ± 10.5^{c}
	Foreigners	72.8 ± 5.8^{a}	95.3 ± 26.6^{b}	83.0 ± 0.0^{ab}	82.8 ± 5.9^{ab}	72.0 ± 0.0^{ab}	75.7 ± 10.2^{a}
	$P^{\#}$	.57	.43	n.a	.39	n.a	**.03***
Lean body mass (Kg)	Cameroonian	46.7 ± 8.0^{a}	51.8 ± 7.3^{b}	51.4 ± 9.4^{ab}	51.3 ± 8.7^{ab}	52.8 ± 10.7^{b}	45.2 ± 8.9^{c}
	Foreigners	47.7 ± 6.4^{a}	56.6 ± 5.5^{b}	58.0 ± 0.0^{ab}	49.7 ± 3.4^{ab}	40.8 ± 0.0^{ab}	47.9 ± 8.4^{ab}
	$P^{\#}$	.92	.21	n.a	.61	n.a	.64
Fatty mass (Kg)	Cameroonian	27.5 ± 11.5^{ac}	33.2 ± 9.2^{bc}	31.7 ± 8.9^{abc}	25.4 ± 10.6^{c}	36.7 ± 10.1^{b}	28.8 ± 10.6^{c}
	Foreigners	17.5 ± 10.7^{ab}	27.4 ± 19.2^{a}	59.0 ± 0.0^{ab}	10.2 ± 4.6^{b}	45.1 ± 0.0^{ab}	17.7 ± 6.1^{a}
	$P^{\#}$	**.0003***	.45	n.a	**.005***	n.a	**.0007***
Water content (%)	Cameroonian	48.9 ± 6.7^{a}	45.6 ± 6.6^{b}	46.9 ± 6.3^{bc}	49.9 ± 3.5^{c}	42.8 ± 4.9^{b}	49.1 ± 6.0^{ac}
	Foreigners	52.9 ± 7.9^{a}	49.1 ± 4.0^{a}	40.9 ± 0.0^{a}	53.9 ± 4.7^{a}	30.2 ± 0.0^{a}	56.5 ± 5.2^{a}
	$P^{\#}$	**.02***	.65	n.a	.07	n.a	**.001***
Bone mass (Kg)	Cameroonian	2.61 ± 0.29^{ac}	2.82 ± 0.29^{bc}	2.86 ± 0.33^{b}	2.76 ± 0.37^{abc}	2.98 ± 0.39^{b}	2.57 ± 0.32^{c}
	Foreigners	2.47 ± 0.26^{a}	3.00 ± 0.43^{b}	2.70 ± 0.00^{ab}	2.65 ± 0.50^{ab}	2.60 ± 0.00^{ab}	2.69 ± 0.26^{ab}
	$P^{\#}$	**.01***	.18	n.a	.41	n.a	.61

Visceral adipose tissue (Kg)	Cameroonian	9.36 ± 4.84[a]	12.67 ± 5.23[b]	9.38 ± 2.45[ab]	11.79 ± 3.09[ab]	13.60 ± 4.96[b]	7.96 ± 4.00[c]
	Foreigners	7.03 ± 2.68[a]	10.13 ± 3.55[a]	8.20 ± 0.00[ab]	7.50 ± 1.91[ab]	17.00 ± 0.00[ab]	6.56 ± 2.58[b]
	P[#]	**.01***	.71	n.a	**.009***	n.a	.09

Data are expressed as mean ± standard deviation (SD); BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, n.a: Not applicable; Comorbidity group consisted of patients with at least two comorbidities seen in the study; [#]Unpaired t-test was used to compare the groups; One-way ANOVA and Duncan's post hoc tests were used to make pairwise comparisons. For a same line, the values with the same letter are not statistically significant at P < .05; [*]Statistically significant at P < .05

Table 6. Factors associated with COVID-19 infection history

	Univariate analysis		Multivariate analysis	
Factors	**COR (95%CI)**	***P***	**AOR (95%CI)**	***P***
Ethnicity				
Cameroonian	1		1	
Foreigner	0.12 (0.02 - 0.92)	**.04***	0.06 (0.01 - 0.76)	**.03***
Gender				
Female	1		1	
Male	1.02 (0.43 - 2.39)	.97	0.65 (0.18 - 2.38)	.51
Age (years)	1.02 (0.99 - 1.05)	.11	1.06 (1.00 - 1.10)	**.03***
BMI (Kg/m^2)	1.04 (0.95 - 1.13)	.44	2.81 (1.65 - 5.77)	**.04***
Glycaemia (g/dL)	0.80 (0.16 - 3.91)	.78	0.27 (0.04 - 1.92)	.19
Lean body mass (Kg)	1.03 (0.98 - 1.09)	.22	1.19 (0.98 - 1.44)	.07
Fatty mass (Kg)	1.02 (0.98 - 1.06)	.32	1.02 (0.93 - 1.11)	.65
Bone mass (Kg)	2.19 (0.65 - 7.34)	.21	0.16 (0.01 - 8.41)	.36
Water content (%)	0.97 (0.91 - 1.03)	.33	0.90 (0.80 - 1.02)	.10
Visceral adipose tissue (Kg)	1.03 (0.94 - 1.12)	.54	0.97 (0.84 - 1.14)	.74
HBV status				
Negative	1		1	
Positive	1.89 (0.79 - 4.45)	.16	2.36 (0.89 - 6.26)	.08
Hypertension				
No	1		1	
Yes	0.74 (0.28 - 1.96)	.54	0.36 (0.10 - 1.24)	.11

*95%CI: Confidence interval at 95%, AOR: Adjusted odds ratio, BMI: Body mass index, COR: Crude odds ratio, COVID-19: Coronavirus disease 2019, HBV: Hepatitis B virus ;Univariate and multivariate logistic regression analyses were performed; *Statistically significant at P < .05*

previous systematic review and meta-analysis on HVB seroprevalence in Cameroon that found a pooled rate of 6.7% in the Littoral region [30]. Similarly, more recent studies reported low rate of HBV infection in Douala, Yaoundé and Dschang towns [29,31]. Even though, we did not find COVID-19 infection, the management of HBV infection could be tricky in Cameroonians in context of the current COVID-19 pandemics. Indeed, utilization of drugs such as corticosteroids and tocilizumab for COVID-19 management is known to cause reactivation of HBV infection [32,33].

Most of the patients had at least two comorbidities which were represented by hypertension, diabetes and obesity. In Douala, Mekolo et al. and Mbarga et al. found high prevalence of hypertension and diabetes in patients hospitalized and suspected for COVID-19 in Douala and Yaoundé towns, respectively [8,9]. Similarly, obesity was reported in > 20% of Cameroonian which is agreed several studies conducted in Douala [14,34,35]. Obesity and overweight are related to changes in lifestyle and food habits (e.g. physical inactivity, overeating) and represent raising public health issues in African countries such as Libya, Namibia, Gabon, South Africa, Zimbabwe, Egypt and Cameroon [36,37]. These changes in lifestyle and food behavior increase risk of cardio-metabolic and hormonal diseases, and could likely explain the high proportion of patients with at least two comorbidities (e.g., hypertension and diabetes).

We found an increased risk of past COVID-19 infection with increasing patient's age, and this is consistent with earlier studies in the country [9,21,38,39]. Other studies outside Cameroon reported advanced age as a risk factor for COVID-19 related infection, severity and death [5]. Physiological mechanisms sustaining the link between age and COVID-19 are still little understood, but impaired host immune response has been largely proposed for explaining higher risk of infection and deteriorated clinical course of COVID-19 infection in patients with advanced age [40]. Likewise, Hong and colleagues showed that blood levels of immunoglobulins G was risk factor for SARS-CoV-2 re-positivity in COVID-19 Chinese patients after discharge [41]. In the same vein with our finding, risk of COVID-19 history was lower in foreigners compared to Cameroonians, and this is likely due to significant differences between these two populations for age, obesity, diabetes and hypertension. Indeed,

foreigners were much younger than local patients. Also, burden of obesity, diabetes and hypertension was higher in Cameroonian patients. Obesity and hypertension are known important risk factors for COVID-19 infection [4,7,13,42].

5. CONCLUSION

The prevalence of COVID-19, determinants and associated comorbidities along with their impact on clinical presentation of COVID-19 were addressed in this study. Vaccine coverage against COVID-19 was very low among Cameroonian patients. No COVID-19 cases were found in the study. In contrast, we reported high rates of comorbidities, especially in Cameroonian population, that were mostly represented by HBV infection, hypertension, diabetes and obesity. A large fraction of the patients had at least two of the above mentioned diseases. Anthropometric, physiological and bioimpedance parameters were influenced by the nature of comorbidities. Age, ethnicity and BMI were determinants of COVID-19 history. This study outlines the importance to manage comorbidities in context of COVID-19 in Cameroon. Further studies should be conducted with more documented investigations about their epidemiology and impact on the natural history of COVID-19 in the country.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. This study was carried out according to the guidelines for human experimental models in clinical research as stated by the Cameroon Ministry of Public Health. Ethical and administrative clearances were issued by the ethics committees of the University of Douala (N 2924 CEI-UDo/10/2021/M), Littoral health regional delegation (N 1328/AAR/MINSANTE/DRSPL/BCASS), and Douala Laquintinie Hospital (N 06713 /AR/MINSANTE/DHL).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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