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Prevalence, Clinical Profile and Determinants of COVID-19 Vaccination and SARS-CoV-2 Breakthrough Infection in Douala, Cameroon

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ABSTRACT

Background and Objective: Vaccination is the most cost-effective public health intervention to control diseases such as the current COVID-19 pandemic. This study aimed to determine the prevalence, clinical profile and determinants of COVID-19 vaccination uptake and SARS-CoV-2 breakthrough infection. **Materials and Methods:** A cross-sectional study was conducted in Douala, Cameroon from January, to September, 2022. A pretested structured questionnaire was used to collect sociodemographic, anthropometric and clinical data of participants during individual interviews. Additionally, findings on COVID-19 vaccination and RT-qPCR based SARS-CoV-2 molecular testing of fully COVID-19 vaccinated patients from medical records. Statistical analyses were performed using StatView, SPSS and GraphPad software. The level of statistical significance was set at $p<0.05$. **Results:** The overall prevalence of COVID-19 vaccination uptake was 18.6%. The prevalence of cough ($p = 0.01$) and sore throat ($p = 0.03$) was higher in unvaccinated patients. The chances of getting vaccinated were increased in those with higher education, elderly people and those with a history of COVID-19 infection. Vaccine breakthrough infections were found at a prevalence of 5.41% and were mainly seen in elderly patients with comorbidities (obesity, hypertension). **Conclusion:** There is a need for adequately tailored information campaigns to sensitize Cameroonian populations on the positive impact of COVID-19 vaccination, especially those with low levels of education.

KEYWORDS

COVID-19 vaccination uptake, breakthrough infection, SARS-CoV-2, clinical profile, COVID-19 pandemics, epidemiology, clinical characteristics

INTRODUCTION

The emergence of pathogens in humans is greatly due to an increased human-animal contact through factors such as expansion of human populations to wildlife and their environment[1]. It is likely through this way that a large number of life-threatening pathogens have emerged in humans. The last example is

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the emergence of the Severe Acute Respiratory Syndrome virus Syndrome Coronavirus (SARS-CoV-2), a betacoronavirus responsible for the current Coronavirus Disease 2019 pandemic (COVID-19)[2,3]. The current global statistics indicate that an estimated 630 million confirmed SARS-CoV-2 cases and ~6.5 million deaths all over the world, as of November 1st, 2022[2] Clinical presentation of COVID-19 is diverse with clinical spectrum ranging from asymptomatic carriage of the SARS-CoV-2 to severe forms and deaths[4,5].

Control measures have been proposed and developed to curb COVID-19 and these include mainly behavioural change-related attitudes such as wearing mask and handwashing[6,7]. To date, there are no efficient therapeutics against COVID-19, even though a myriad of options has been evaluated so far (e.g., repurposed drugs, monoclonal antibodies)[4]. Vaccination remains the most effective public health intervention to control infectious diseases. A modelling study pointed out that COVID-19 vaccination saved tens of millions of lives globally[8]. A limited number of COVID-19 vaccines are currently available and these are either endorsed by the World Health Organisation (WHO), food drug administration and some countries (e.g., China, Russia). The main COVID-19 vaccines include the Oxford/AstraZeneca (ChAdOx1-S [recombinant]) vaccine, the Janssen Ad26.COV2.S COVID-19 vaccine, The moderna COVID-19 (mRNA-1273) vaccine and The Pfizer BioNTech (BNT162b2) COVID-19 vaccine[9-11].

Existing evidences suggest that current COVID-19 vaccines are safe and efficient to prevent complications and deaths in COVID-19 patients[12-14]. Even though not avoiding SARS-CoV-2 transmission to humans, COVID-19 vaccines are moderately-to-highly effective against the main Alpha, Beta and Delta lineages of the SARS-CoV-2[12-14]. Again, side effects reported in COVID-19 vaccinated people are generally mild (e.g, fever, fatigue, pain)[9-11]. Unfortunately, providing and coverage rates with COVID-19 vaccines are unjustly unequal between developed and developing countries, with dramatically low rates in resource-constrained areas such as African countries. Furthermore, a systematic review and meta-analysis outlined relatively low global acceptance and uptake of COVID-19 vaccination, with values of 67.8 and 42.3%, respectively[15]. The COVID-19 is still an important public health concern in Cameroon, despite the arsenal of strategies deployed to control the pandemic[16,17]. A national plan has been defined to implement and scale up COVID-19 vaccination in the country through the COVID-19 Vaccines Global Access (COVAX) Facility initiative, in association with, WHO[18].

The present study was designed to determine coverage level, clinical profile and determinants of COVID-19 vaccination in Douala, Cameroon. Additionally, the prevalence and characteristics of SARS-CoV-2 breakthrough infections were also determined.

MATERIALS AND METHODS

Study design and sites: A hospital-based cross sectional study was conducted in the town of Douala, Littoral Region, Cameroon from January to September, 2022. Douala is the main business and most populous town of the country, which is characterized by a high ethnic diversity mainly represented by *Duala*, *Bassa* and *Bamileke* groups[19]. In the early of COVID-19 pandemics, the Government of Cameroon encouraged the implementation of control measures including vaccination. Sites of seven health facilities were selected in this study to recruit participants namely Bangue District Hospital, Boko Health Care Centre, Bonassama District Hospital, *Cité des* Palmiers District Hospital, Deido District Hospital, New Bell District Hospital and Nylon District Hospital. The selection of health facilities as study sites was driven by high attendance rates in these facilities and the implementation of diagnostic and treatment plateforms for COVID-19 management.

Participants and sample size: All Cameroonian patients coming for routine check-up or attending outpatient departments of either of the above mentioned health facilities, of both sexes, aged more than 18 years old, living permanentlyin Douala and who gave their consent to participate in the study. In contrast, individuals who declined the invitation to take part in the study, reluctant to sign written informed consent forms and foreigners were not enrolled. In order to prevent the risk of selection or

information biases, the selection of participants was based on a consecutive inclusion using random sampling approach. The minimum sample size reauired for the study was computed using the Lwanga and Lemeshow's formula[20]. The statistical parameters included level of confidence (95%), a 10% non-response rate and proportion of COVID-19 vaccination coverage (42.3%)[15]. The minimum sample size for the study was estimated at n = 412.5 ≈413 participants.

Data collection and management: An investigator-administered pretested structured questionnaire was used to collect data of interest during 20 min individual interviews. Data were collected by master and final-year doctoral students. The first part of the questionnaire was designed to collect sociodemographic information (gender, age, occupation, marital status and level of education). The second part captured clinical and anthropometric information including comorbidities (i.e., the co-occurrence of more than health disorder in the same patient). The third part focused on COVID-19 related information such as history of SARS-CoV-2 infection, COVID-19 vaccination, nature and number of doses of the COVID-19 vaccine.

Clinical signs and symptoms presented by participants were diagnosed and reported by medical doctors. Anthropometric data were weight, height and body mass index (BMI). The Quetelet's formula was used to calculate BMI (kg m^{-2}) = weight/(height)^2. Obesity was defined as BMI $\geq$25 kg m^{-2}. A patient was considered fully COVID-19 vaccinated if he/she had received the number of doses required for a given vaccine. For instance, the required dosage for the Oxford/AstraZeneca COVID-19 vaccine is two doses given intramuscularly (0.5 mL each) with an interval of 8-12 weeks[7,18].

Sources of information included patients medical records, vaccination card, declaration of patients and discussion with medical doctors. Finally, findings on RT-qPCR based SARS-CoV-2 molecular testing of fully COVID-19 vaccinated patients were collected from medical records. This information allowed to determine rate of SARS-CoV-2 breakthrough infection (i.e., presence of SARS-CoV-2 infection among fully vaccinated persons for COVID-19)[21].

Data quality control: Field investigators were trained on how to conduct interview and collect data. A pre-test was done on 15 participants who were not included in the study and questions were adjusted based on any remarks/discrepancy/misunderstanding. Close supervision of data collectors was carried out by senior and supervising investigators. The internal consistency of questionnaire was determined using the Cronbachs alpha[22]. A Cronbach's alpha value of 0.713 was obtained for the study questionnaire. Data collected from each participant were entered in an Excel spreadsheet, coded and double-checked for consistency completeness and missing data. Any discrepancy was resolved through discussion, consensus and discussion with senior and supervising investigators.

Statistical analysis: Statistical analysis was performed using StatView v5.0 (SAS Institute, Chicago, Inc., Illinois, United States of America), statistical package for social sciences-SPSS v16 (SPSS IBM, Inc., Chicago, Illinois, United States of America) and GraphPad v5.03 (GraphPad PRISM, San Diego, Inc., California, United States of America) software. Categorical variables were summarized as percentages with 95% confidence intervals (95% CI), while continuous variables were presented as Mean±Standard deviation (SD). Pearson's independence Chi Square and Fisher's Exact Tests were used to compare proportions. Univariate and multivariate logistic regression analyses were used to identify determinants of COVID-19 vaccination coverage. The association between independent variables and COVID-19 vaccination coverage was analyzed by calculating crude and adjusted values of odds ratios (cOR and aOR). These estimates were then converted into corresponding risk ratios (RR) as described by Zhang and Yu[23]. A $p<0.05$ was considered statistically significant for all analyses.

Ethical statements: Ethical clearances were issued by the institutional review boards of University of Douala (N°2945 CEI-UDo/12/2021/T) and the Littoral health regional delegation (N°0038/AAR/MINSANTE/DRSPL/BCASS). Each participant who signed a written informed consent

form was ensured on the anonymisation and confidentiality of their personal information. Participation was voluntary and without financial compensation.

RESULTS

Participants included in the study: During the study period, a total of 2354 individuals were approached at the health facilities. After exclusion of 1934 individuals based on the exclusion criteria, 420 individuals agreed to participate to the study (Fig. 1).

Characteristics of participants: The study population was mainly constituted of males (52.9%), giving a male-to-female ratio sex of 1.12. Patients aged ≥60 years accounted for 16% of the participants. Most of the participants were had completed university studies (60.5%). Based on medical records and discussion with participants and medical doctors, comorbidities such as diabetes and hypertension were reported in 6.4 and 11.2%, respectively (Table 1).

Proportion of COVID-19 vaccination uptake: Of the 420 individuals included in the study, 78 individuals received at least one vaccine dose. Thus, the prevalence of COVID-19 vaccination uptake was 18.6% (95, CI 15.1-22.6%).

Type and completeness of COVID-19 vaccination: Patients were COVID-19 vaccinated with 5 types of vaccines: Johnson and Johnson, Sinopharm, Oxford/AstraZeneca, Moderna and Pfizer BioNTech. Vaccine coverage was mainly achieved with Janssen (34.6%), Sinopharm (24.4%) and Oxford/AstraZeneca (20.5%) (Table 2). Of the 78 vaccinated, 74 (94.9%) of them were fully vaccinated. Of note, six patients received two different types of COVID-19 vaccines, 4 received Moderna+Pfizer BioNTech, one received Oxford/AstraZeneca+Pfizer BioNTech and one received Pfizer BioNTech+Sinopharm.

Table 1: Sociodemographic, anthropometric and clinical characteristics of the participants included in the study

Characteristics	n (%)
Sociodemographic characteristics	
Male, n (%)	222 (52.9%)
Age ≥60 years, n (%)	68 (16.0%)
Mean age±SD (years)	42.3±14.4
Single, n (%)	182 (43.3%)
University level, n (%)	254 (60.5%)
Non-medical formal sector, n (%)	241 (57.4%)
Anthropometric characteristics	
Weight±SD (Kg)	78.56±15.59
Height±SD (m)	1.69±0.11
BMI±SD (kg m^2)	27.54±5.14
Clinical characteristics	
At least one comorbidity, n (%)	161 (38.3%)
Obesity, n (%)	114 (27.1%)
Hypertension, n (%)	47 (11.2%)
Diabetes, n (%)	27 (6.4%)
Asthma, n (%)	12 (2.9%)
Heart failure, n (%)	10 (2.4%)
HIV, n (%)	8 (1.9%)
Cancer, n (%)	3 (0.7%)
Stroke, n (%)	3 (0.7%)
Coronary heart disease, n (%)	1 (0.2%)
Renal impairment, n (%)	1 (0.2%)
Gastroenteritis, n (%)	0 (0%)
Gout, n (%)	0 (0%)
Malaria, n (%)	0 (0%)

Data are presented as frequency (n) and percentages (%) or Mean±Standard deviation (DS), BMI: Body mass index and HIV: Human immunodeficiency virus

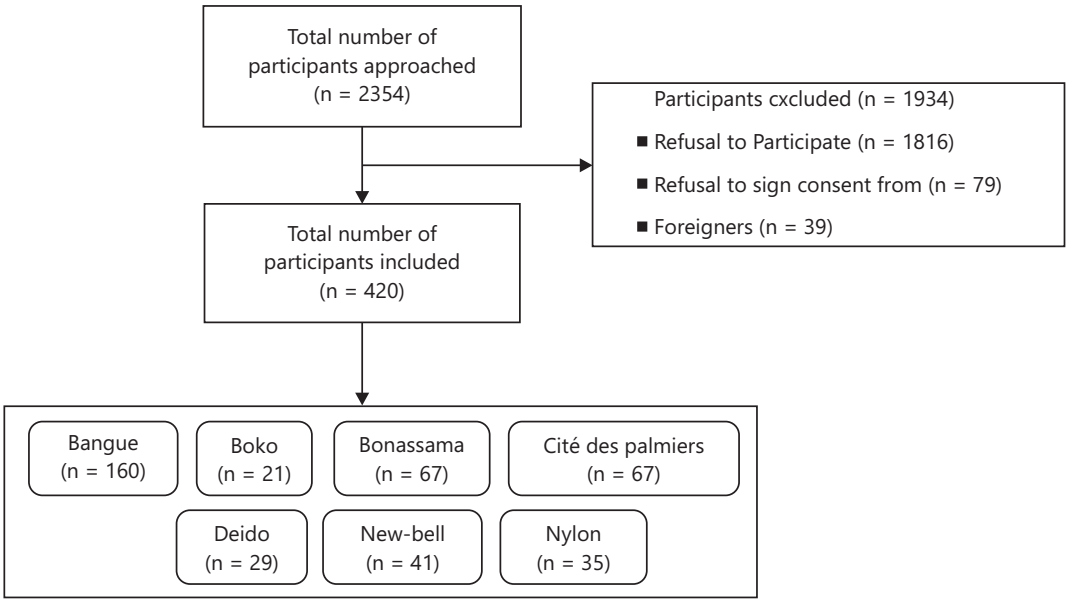

Fig 1: Flowchart diagram summarizing enrolment of the participants

Table 2: Types of COVID-19 vaccines by regard to vaccine status of the participants

	Fully vaccinated		Partially vaccinated		Total	
COVID-19 vaccines	n	(%)	n	(%)	n	(%)
Janssen	27	36.5	0	0.0	27	34.6
Sinopharm	19	25.6	0	0.0	19	24.4
Oxford/AstraZeneca	16	21.6	0	0.0	16	20.5
Pfizer BioNTech	9	12.2	0	0.0	9	11.5
Moderna+Pfizer BioNTech	2	2.7	2	50.0	4	5.1
Moderna	1	1.4	0	0.0	1	1.3
Oxford/AstraZeneca+Pfizer BioNTech	0	0.0	1	25.0	1	1.3
Pfizer BioNTech+Sinopharm	0	0.0	1	25.0	1	1.3
Total	74	100.0	4	100.0	78	100.0

Data are presented as frequency (n) and percentages (%)

Clinical symptoms by vaccination status: Most of patients presented clinical symptoms, which were mainly represented by cough, severe fatigue and headache. Overall, prevalence of clinical symptoms was higher in unvaccinated patients, with statistically significant difference for cough ($p = 0.01$) and sore throat ($p = 0.03$). No clinical symptoms were reported in partially vaccinated patients (Fig. 2).

Prevalence of SARS-CoV-2 breakthrough infection: Of the 74 fully COVID-19 vaccinated patients, SARS-CoV-2 was detected by RT-qPCR in four patients, giving a prevalence of 5.41% (95% CI 2.12-13.1%).

Characteristics of patients with SARS-CoV-2 breakthrough infection: On analysis of patients with SARS-CoV-2 breakthrough infection, it was noted that most of them were elderly, married and had completed secondary studies. Obesity and hypertension were main comorbidities reported in these four patients (Fig. 3a). Three of these patients were fully vaccinated with Oxford/AstraZeneca vaccine while the remaining patient was vaccinated with Janssen vaccine. A total of 13 clinical signs/symptoms were reported and were more frequently seen in those vaccinated with Oxford/AstraZeneca vaccine (Fig. 3b).

COVID-19 vaccination coverage, sociodemographic and clinical information: The distribution of COVID-19 vaccinated patients with regard to sociodemographic and clinical information is summarised in Table 3-4. The proportion of COVID-19 vaccination uptake was significantly higher in those attending

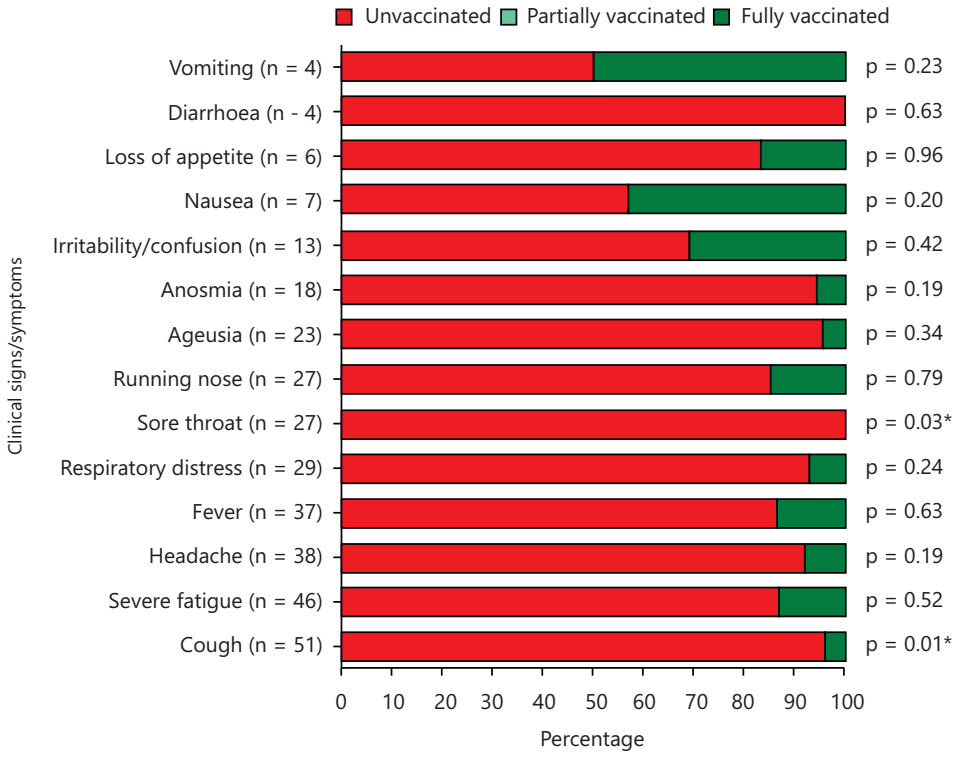

Fig 2: Distribution of clinical symptoms by COVID-19 vaccination status

Number (n) of participants having presented each clinical symptom is given, Pearson's independence Chi-Square Test was used to compare proportion and *Statistically significant at p<0.05

Table 3: COVID-19 vaccination uptake and sociodemographic characteristics

Variables	Categories	N	n (%)	χ2 (df)	p-value
Health facility	Bangue	160	52 (32.5%)	39.9 (6)	<0.0001*
	Boko	21	2 (9.5%)		
	Bonassama	67	5 (7.5%)		
	Cité des Palmiers	67	4 (6.0%)		
	Deido	29	7 (24.1%)		
	New-Bell	41	2 (4.9%)		
	Nylon	35	6 (17.1%)		
Age groups (years)	<30	98	16 (16.3%)	13.4 (5)	0.02*
	(30-40)	115	15 (13.0%)		
	(40-50)	78	14 (17.9%)		
	(50-60)	61	10 (16.4%)		
	(60-70)	51	17 (33.3%)		
	70^{+}	17	6 (35.3%)		
Gender	Females	198	35 (17.7%)	-	0.71
	Males	222	43 (19.4%)		
Matrimonial status	Single	182	32 (17.6%)	0.59 (2)	0.74
	Married	223	44 (19.7%)		
	Divorced/widow (er)	15	2 (13.3%)		
Level of education	None/primary	25	3 (12.0%)	1.12 (2)	0.57
	Secondary	141	29 (20.6%)		
	University	254	46 (18.1%)		
Occupation	Student	50	9 (18.0%)	0.33 (2)	0.84
	Formal sector	283	51 (18.0%)		
	Informal sector	87	18 (20.7%)		

Independence pearsons Chi-Square Test was used to compare percentages, χ^2: Decision variable of Chi-Square Test, df: Degree of freedom and *Statistically significant at p<0.05

site of the Bangue District Hospital (32.5%, p<0.0001), those aged ≥70 years old (35.3%, p = 0.02), obese (26.3%, p = 0.01) and those having history of infection (38.8%, p<0.0001).

(a)

	Patient 1	Patient 2	Patient 3	Patient 4
Sociodemographical characteristics				
Sites	New-bell	Bangue	Bangue	Bangue
Age (years)	41	62	74	74
Gender	Female	Female	Male	Male
Marital status	Married	Married	Married	Married
Educational level	Secondary	Secondary	Secondary	Secondary
Occupation	Haircut maker	Housewife	Businessman	Retired
Clinical characteristics				
Obesity	Yes	Yes	Yes	Yes
Diabetes	No	No	No	No
Hypertension	No	Yes	Yes	Yes
Stroke	No	No	No	Yes
Heart failure	Yes	No	No	No
Cancer	No	No	No	No
HIV	Yes	No	No	No
Asthma	Yes	No	No	No
Renal impairment	No	No	Yes	No

(b)

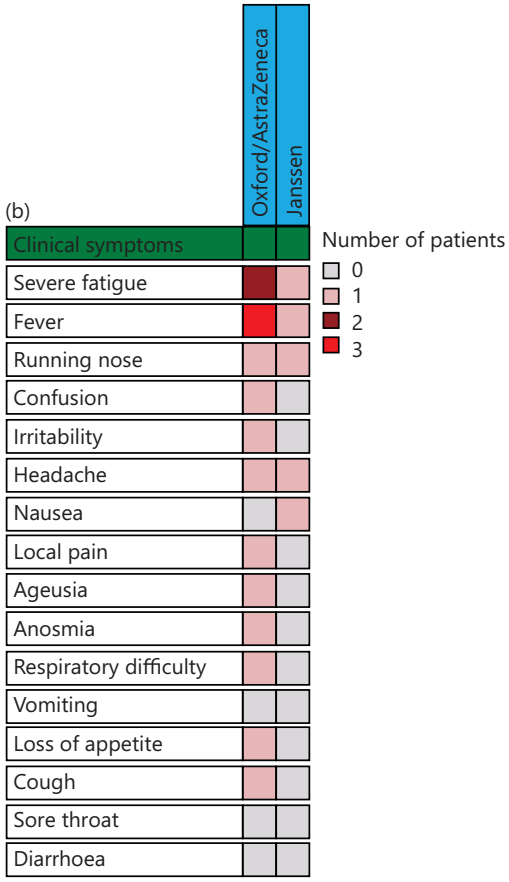

Fig. 3(a-b): Characteristics of fully vaccinated patients with SARS-CoV-2 breakthrough infection, (a) Sociodemographic and clinical profile and (b) Clinical signs/symptoms presented

Determinants of COVID-19 vaccination uptake: Based on univariate logistic regression analysis, 4 determinants were found to be associated with COVID-19 vaccination uptake namely health facility, age, obesity and history of COVID-19 infection (Table 5). The odds of getting vaccinated were reduced by 52-76% in patient attending Boko health care centre (aRR = 0.48, 95% CI 0.07-0.98, p = 0.04), Bonassama district hospital (aRR = 0.37, 95%CI 0.09-0.54, p = 0.0003), *Cité des* Palmiers District Hospital

Table 4: COVID-19 vaccination uptake and clinical characteristics

Variables	Categories	N	n (%)	χ2 (df)	p-value
Obesity	No	306	48 (15.7)	-	0.01*
	Yes	114	30 (26.3)		
Diabetes	No	393	72 (18.3)	-	0.61
	Yes	27	6 (22.2)		
Hypertension	No	373	68 (18.2)	-	0.69
	Yes	47	10 (21.3)		
Heart failure	No	410	76 (18.5)	-	0.91
	Yes	10	2 (20.0)		
HIV	No	412	75 (18.2)	-	0.17
	Yes	8	3 (37.5)		
Asthma	No	408	77 (18.9)	-	0.71
	Yes	12	1 (8.3)		
History of COVID-19	No	353	52 (14.7)	21.6 (1)	<0.0001*
	Yes	67	26 (38.8)		

Independence pearsons Chi-Square Test was used to compare percentages, χ^2: Decision variable of Chi-Square Test, df: Degree of freedom and *Statistically significant at p<0.05

Table 5: Univariate logistic regression of determinants COVID-19 vaccination uptake

Variables	Categories	cOR (95%CI)	aRR (95%CI)	p-value
Sociodemographic characteristics				
Health facility	Bangue	1	1	
	Boko	0.22 (0.05-0.97)	0.48 (0.07-0.98)	0.04*
	Bonassama	0.17 (0.06-0.44)	0.37 (0.09-0.54)	0.0003*
	Cité des Palmiers	0.13 (0.05-0.38)	0.28 (0.07-0.48)	0.002*
	Deido	0.66 (0.27-1.65)	1.32 (0.35-1.36)	0.37
	New-Bell	0.11 (0.02-0.46)	0.24 (0.03-0.56)	0.002*
	Nylon	0.43 (0.17-1.10)	0.90 (0.23-1.07)	0.07
Age groups (years)	<30	1	1	
	(30-40)	0.77 (0.36-1.65)	1.07 (0.40-1.49)	0.49
	(40-50)	1.12 (0.51-2.47)	1.53 (0.55-1.99)	0.77
	(50-60)	1.00 (0.42-2.38)	1.38 (0.52-1.64)	0.99
	(60-70)	2.56 (1.16-5.65)	2.93 (1.13-3.21)	0.01*
	70^{+}	2.80 (1.10-8.65)	3.08 (1.08-3.85)	0.005*
Gender	Females	1	1	
	Males	1.12 (0.68-1.83)	1.56 (0.72-1.60)	0.65
Matrimonial status	Single	1	1	
	Married	1.15 (0.70-1.91)	1.60 (0.74-1.65)	0.58
	Divorced/widow (er)	0.72 (0.16-3.35)	1.04 (0.19-2.37)	0.67
Level of education	None/primary	1	1	
	Secondary	1.90 (0.53-6.79)	2.30 (0.56-4.01)	0.32
	University	1.62 (0.47-5.65)	2.01 (0.50-3.63)	0.44
Occupation	Student	1	1	
	Formal sector	1.00 (0.46-2.19)	1.42 (0.51-1.80)	0.99
	Informal sector	1.19 (0.49-2.89)	1.66 (0.54-2.16)	0.70
Clinical characteristics				
Obesity	No	1	1	
	Yes	1.92 (1.14-3.22)	2.40 (1.12-2.80)	0.01*
Diabetes	No	1	1	
	Yes	1.27 (0.50-3.27)	1.76 (0.55-2.31)	0.61
Hypertension	No	1	1	
	Yes	1.21 (0.57-2.56)	1.69 (0.62-1.99)	0.61
Heart failure	No	1	1	
	Yes	1.10 (0.23-5.28)	1.56 (0.27-2.95)	0.91
HIV	No	1	1	
	Yes	2.70 (0.63-11.53)	2.97 (0.68-3.95)	0.18
Asthma	No	1	1	
	Yes	0.39 (0.05-3.07)	0.59 (0.06-2.21)	0.37
History of COVID-19	No	1	1	
	Yes	3.67 (2.07-6.51)	3.60 (1.79-4.68)	<0.0001*

Univariate logistic regression analysis was used to identify factors associated with COVID-19 vaccination uptake, COVID-19: Coronavirus disease 2019, 95%CI: Confidence interval at 95%, cOR: Crude odds ratio, aRR: Adjusted risk ratio, HIV: Human immunodeficiency virus, SARS-CoV-2: Severe acute respiratory syndrome Coronavirus 2 and *Statistically significant at p<0.05

Table 6: Multivariate logistic regression of determinants COVID-19 vaccination uptake

Variables	Categories	aOR (95%CI)	aRR (95%CI)	p-value
Sociodemographic characteristics				
Health facility	Bangue	1	1	
	Boko	0.21 (0.04-0.94)	0.46 (0.06-0.96)	0.03*
	Bonassama	0.13 (0.04-0.37)	0.28 (0.06-0.47)	0.0002*
	Cité des Palmiers	0.08 (0.02-0.27)	0.18 (0.03-0.35)	<0.0001*
	Deido	0.64 (0.23-1.78)	1.28 (0.31-1.42)	0.38
	New-Bell	0.07 (0.01-0.34)	0.15 (0.01-0.43)	0.001*
	Nylon	0.47 (0.17-1.31)	0.98 (0.23-1.19)	0.14
Age groups (years)	<30	1	1	
	(30-40)	0.89 (0.32-2.47)	1.23 (0.36-1.99)	0.82
	(40-50)	1.42 (0.46-4.34)	1.88 (0.50-2.81)	0.54
	(50-60)	1.62 (0.44-6.01)	2.10 (0.48-3.31)	0.46
	(60-70)	4.17 (1.19-14.56)	3.59 (1.15-4.54)	0.02*
	70^{+}	8.37 (1.30-54.03)	3.27 (1.24-5.60)	0.02*
Gender	Females	1	1	
	Males	1.42 (0.75-2.69)	1.92 (0.78-2.07)	0.27
Matrimonial status	Single	1	1	
	Married	0.56 (0.27-1.17)	0.81 (0.31-1.14)	0.12
	Divorced/widow (er)	0.44 (0.06-3.23)	0.64 (0.07-2.32)	0.42
Level of education	None/primary	1	1	
	Secondary	3.19 (1.60-17.12)	3.46 (1.49-5.83)	0.01*
	University	2.24 (0.38-13.08)	2.65 (1.41-5.34)	0.03*
Occupation	Student	1	1	
	Formal sector	0.87 (0.28-2.68)	1.25 (0.32-2.06)	0.81
	Informal sector	1.29 (0.32-5.19)	1.78 (0.36-2.96)	0.72
Clinical characteristics				
Obesity	No	1	1	
	Yes	2.29 (1.21-4.71)	2.73 (1.17-2.98)	0.01*
Diabetes	No	1	1	
	Yes	1.48 (0.45-4.85)	2.00 (0.50-2.85)	0.51
Hypertension	No	1	1	
	Yes	0.61 (0.21-1.72)	0.90 (0.25-1.52)	0.34
Heart failure	No	1	1	
	Yes	1.04 (0.12-9.16)	1.48 (0.14-3.65)	0.97
HIV	No	1	1	
	Yes	2.69 (0.42-17.05)	2.96 (0.47-4.35)	0.29
Asthma	No	1	1	
	Yes	0.65 (0.07-5.93)	0.97 (0.08-3.07)	0.70
History of COVID-19	No	1	1	
	Yes	3.63 (1.79-7.35)	3.59 (1.60-3.80)	0.0003*

Multivariate logistic regression analysis was used to identify factors associated with COVID-19 vaccination uptake. COVID-19: Coronavirus disease 2019, 95% CI: Confidence interval at 95%, aOR: Adjusted odds ratio, aRR: Adjusted risk ratio, HIV: Human immunodeficiency virus, SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2 and *Statistically significant at p<0.05

(aRR = 0.28, 95%CI 0.07-0.48, p = 0.002) and New Bell District Hospital (aRR = 0.24, 95%CI 0.03-0.56 and p = 0.002), compared to those attending the site of the Bangue District Hospital.

Conversely, the chances of COVID-19 vaccination uptake were increased by ~three times in patients aged 60-70 years (aRR = 2.93, 95%CI 1.13-3.21, p = 0.01) and by three times in patients aged ≥70 years (aRR = 3.08, 95%CI 1.08-3.85, p = 0.005), compared to their counterparts aged 30 years. Likewise, obese patients had more than 2 times chances to get vaccinated (aRR = 2.40, 95%CI 1.12-2.80, p = 0.01) compared to non-obese patients. Finally, the odds of COVID-19 vaccination uptake were increased by ~4 times in patients having had COVID-19 infection (aRR = 3.60, 95%CI 1.79-4.68 and p<0.0001).

The findings of univariate logistic analysis were confirmed by those of multivariate logistic analysis, given the fact that health facility, age, obesity and history of COVID-19 infection were determinants of COVID-19 vaccination uptake. Level of education was additional determinants of COVID-19 vaccination uptake Table 6). Indeed, the chances of getting COVID-19 vaccination uptake were increased by ~4 times in those

having completed secondary studies (aRR = 3.46, 95%CI 1.49-5.83 and p = 0.01) and by ~3 times in those having completed university studies (aRR = 2.65, 95%CI 1.41-5.34 and p = 0.03), compared to those with none/primary study level (Table 6).

DISCUSSION

Vaccination is a crucial public health measure to control infectious diseases. In this study, prevalence, clinical profile and determinants of COVID-19 vaccination uptake and SARS-CoV-2 breakthrough infection were determined among individuals. The overall prevalence of COVID-19 vaccination uptake was 18.6%. The chances of getting vaccinated were increased in those with higher education, elderly people and those with a history of COVID-19 infection. Vaccine breakthrough infections were found at a prevalence of 5.41% and were mainly seen in elderly patients with comorbidities (obesity, hypertension).

The COVID-19 vaccination uptake was relatively low in the study, which is lower than that reported previously in Cameroon[24,25] and a global estimate of COVID-19 vaccination uptake rate reported by Zhang and colleagues[15]. Other studies reported higher vaccine uptake in specific groups such as elderly persons, college students and transborder populations[26-28]. Several factors drive the intention to accept, delay and abstain from vaccination and these include trust in vaccine approval, the perceived effectiveness of the vaccine for protecting others and conspiracy beliefs[29,30]. This phenomenon also known as COVID-19 vaccine hesitancy is well known in Cameroon[31-33] and other African countries[34].

Interestingly, few cases of SARS-CoV-2 breakthrough infections were found at prevalence of 5.41% in this study. Similar to higher breakthrough infection rates were reported recently in India (5.6 and 16.8%)[35,36]. This finding was the first report of such data in Cameroon and support the fact that current COVID-19 vaccines, even though highly efficient to prevent severe clinical forms of the disease, do not prevent SARS-CoV-2 transmission[12,14]. Most of these SARS-CoV-2 breakthrough infections were seen in elderly patients with comorbidities (obesity, hypertension). This result was consistent with that reported by Duarte *et al.*[37] and is not surprising as advanced age and comorbidities are risk factors of severe clinical forms and adverse outcomes[38]. In Qatar, Butt and colleagues[39] found an increased risk of severe COVID-19 and deaths in aged patients with vaccine breakthrough infection. Similar findings were also reported in Tunisia and Italy[40,41]. Other factors such as waning immunity, type of vaccines and SARS-CoV-2 variants (e.g., Omicron, Delta) can also modulate natural history of infection and thus shaped risk of vaccine breakthrough infection in populations[42-45], especially in vulnerable groups such as elderly people, even in whom booster vaccine dose can fail to prevent breakthrough infection as recently reported[46].

Advanced age was positively associated with COVID-19 vaccine uptake and this finding was reported previously[30,47-49]. It is now well described that elderly people are more at risk of complications and deaths due to COVID-19 infection. Thus, elderly patients or their relatives may confront the disease with more anxiety and fear, thereby resulting in an increased chances of vaccination rates in them. This perception of dangerousness towards COVID-19 among elderly patients could also explain why obese patients had more chances to get vaccinated. Zhao and colleagues reported similar finding among Chinese patients[47]. Obesity is also a strong risk factors of complications and mortality in COVID-19 infected patients[38,50]. Also, sensitisation actions implemented by Government of Cameroon, might also encouraged these patients to take the vaccine. Moreover, during COVID-19 crisis period, most of the countries have first targeted groups at risk of severe and deaths (elderly people, those with comorbidities) during vaccination campaigns. Several studies reported high vaccination rates in high-risk groups[51,52].

In this study, vaccination uptake rate was increased in patients with higher level of education, which support findings from studies conducted elsewhere[27,30,49,53]. Higher educational level is known to be associated with better access and understanding of knowledge on dangerousness and prevention of diseases. The impact positive of higher educational level on preventive practices has been showed for other important diseases such as malaria[54,55].

This study has several limitations. Firstly, other potential drivers of COVID-19 vaccine non-uptake such as interpersonal, anthropological and social factors were not investigated in the present study[27,28,56] and this constitutes a main limitation of the study. Secondly, information on molecular typing of SARS-CoV-2 lineage found in fully vaccinated patients is lacking and this might have introduced interpretation bias. Thirdly, it was tricky to objectively distinct clinical signs/symptoms due to SARS-CoV-2 infection, COVID vaccine and other concurrent infections or ailments (e.g., malaria, bacterial and viral infections). Finally, this study was conducted in Douala and thus findings are not generalizable to whole Cameroonian population. Despite these limitations this study provides the first insights into prevalence of COVID-19 vaccination and SARS-Cov-2 breakthrough infection in Douala, the most populous town of Cameroon. Futhermore, this study outlines the need to develop information, education and communication strategies to improve COVID-19 vaccination coverage in young population and patients with low education.

CONCLUSION

This is the first report on prevalence and determinants of COVID-19 vaccination uptake, along with associated side effects. COVID-19 vaccine uptake rate was relatively low in the participants. Advanced age, higher level of education, health facility, presence of comorbidity (obesity) and history of COVID-19 were determinants of COVID-19 vaccination uptake. Twelve side effects were reported following COVID-19 vaccination uptake and these were mainly mild. In a context of high vaccine hesitancy in African populations, there is a need for adequately tailored information campaigns to sensitize Cameroonian populations on positive impact of COVID-19 vaccination, especially in elderly persons and those with low level of education and comorbidities.

SIGNIFICANCE STATEMENT

The COVID-19 is still an important public health concern in Cameroon, despite the arsenal of strategies deployed to control the pandemic including vaccination. This study aimed at determining prevalence, clinical profile and determinants of COVID-19 vaccination uptake and SARS-CoV-2 breakthrough infection in Douala, Cameroon. The study outlines a low vaccination coverage, with higher education, older age and past COVID-19 infection as main determinants. Patients were vaccinated mainly with Janssen, Sinopharm and Oxford/AstraZeneca vaccines. Vaccine breakthrough infections were found at a prevalence of 5.41% and were mainly seen in elderly patients with comorbidities including obesity and hypertension. This study pinpoints the need for ongoing surveillance of SARS-CoV-2 and increased vaccination coverage in Cameroon.

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