JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Coronavirus Pandemic

Cumulative seroprevalence of SARS-CoV-2 antibodies among blood donors in Burkina Faso, April 2022

Salam Sawadogo[1,2], Yacouba Diallo[1], Koumpingnin Nebie[1,2], Bertrand Ivlabèhirè Meda[3], Corneille Ydriss Djerma[4], Georges Pengdwendé Ouedraogo[5], Donatien Kima[1], Serge Mamadou Sawadogo[6], Amadou Kafando[7], Sinaré Coulibaly[8], Bachirou Cheickh Ashmed Nana[9], Dieudonné Yetema Yonli[9], Martin Ouedraogo[10], Anita Pierrette Siritie[5], Sylvie Zida[3], Charlemagne Sanhitouo Dabire[3], Rakiatou Traore[11], Kadidiatou Aïna Konate[12], Anita Benao[8], Seimbou Zalla[2], Sonia Sontie[2], Veronique Deneys[13], Eléonore Kafando[1], Gautier Henri Ouedraogo[3]

[1] *Laboratory of Haematology, University Joseph KI-ZERBO, Ouagadougou, Burkina Faso*
[2] *National Blood Transfusion Centre, Ouagadougou, Burkina Faso*
[3] *Health Sciences Research Institute , Ouagadougou, Burkina Faso*
[4] *Regional blood transfusion centre of Gaoua, Burkina Faso*
[5] *Regional blood transfusion centre of Koudougou, Burkina Faso*
[6] *Regional blood transfusion centre of Tenkodogo, Burkina Faso*
[7] *Regional blood transfusion centre of Ouahigouya, Burkina Faso*
[8] *Regional blood transfusion centre of Ouagadougou, Burkina Faso*
[9] *Regional blood transfusion centre of Bobo-Dioulasso, Burkina Faso*
[10] *Regional blood transfusion centre of Fada N'Gourma, Burkina Faso*
[11] *Regional blood transfusion centre of Kaya, Burkina Faso*
[12] *Regional blood transfusion centre of Dédougou, Burkina Faso*
[13] *Catholic University of Louvain, Brussels, Belgium*

Abstract

Introduction: In Sub-Saharan Africa, the true extent of the COVID-19 pandemic is not known due to the low number of tests performed and the large proportion of asymptomatic cases in the populations. This was a seroprevalence study of SARS-CoV-2 antibodies in blood donors to assess the extent of virus circulation in Burkina Faso.

Methodology: It was a cross-sectional study that included unpaid blood donors between March and April 2022. A rapid diagnostic test was used to screen SARS-CoV-2 antibodies in donors' plasma. Adjustment was made based on the performance of the test evaluated in a national quality control.

Results: A total of 3,084 blood donors were recruited, of whom 58.7% were male and 59.8% were from urban areas. The mean age was 22.9 ± 5.8 years, with donors aged 20 to 29 years accounting for 64.2%. The adjusted seroprevalence was 87.2%; 95% CI (86.4– 87.9). There was no difference in SARS-CoV-2 seropositivity between men and women, and between urban and rural areas. Donors aged 30-39 years had 0.5-fold lower odds of having SARS-CoV-2 antibodies than those under 20. Similarly, compared to Bobo-Dioulasso, blood donors from the Dédougou, Fada N'Gourma, and Koudougou centres had 0.5, 0.2, and 0.5 times lower odds of having SARS-CoV-2 antibodies, respectively.

Conclusions: The study indicates a high population exposure to SARS-CoV-2, in contrast with the official reports from the national surveillance system. It underscores the need to strengthen surveillance and public health interventions both in urban and rural areas.

Key words: COVID-19; SARS-CoV-2; antibodies; blood donors; seroprevalence; Burkina Faso.

J Infect Dev Ctries 2025; 19(3):353-361. doi:10.3855/jidc.18381

(Received 14 April 2023 – Accepted 12 July 2023)

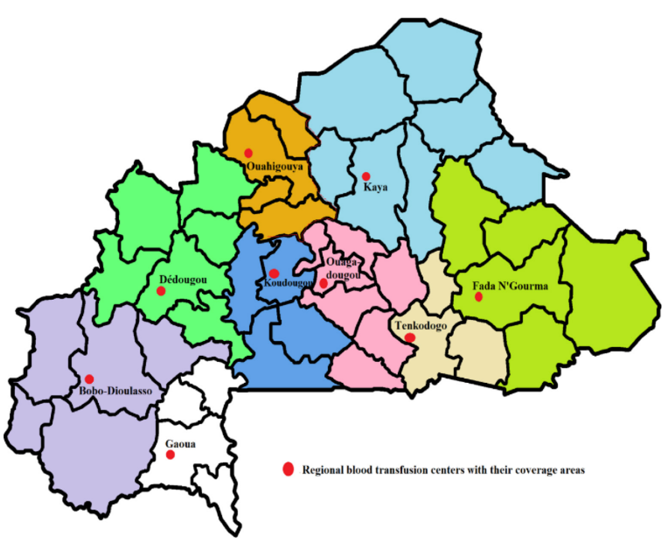
Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) broke out in Wuhan, China in December 2019 [1]. Within weeks, it was declared a global health emergency by the World Health Organization (WHO), regarding both, "*the alarming levels of spread and severity and by the alarming levels of inaction*". A call was made to all countries to take measures to contain the spread of the virus [1]. On March 11, 2020, it was declared a global pandemic [2]. As of January 20, 2023, WHO reported 663,640,386 confirmed cases globally with 6,713,093 deaths worldwide. In Sub-Saharan Africa, the cumulative number of confirmed cases and deaths were respectively 9,466,921 and 175,177. Compared to the other continents, Africa had fewer number of reported cases [3]. However, this low number of cases in Africa is far from reflecting the real extent of the epidemic on the continent. Indeed, it is known that the number of cases of a disease detected and reported depends largely on, among others, the availability and accessibility of screening tests, the effectiveness of the epidemiological surveillance system, and the clinical presentation of the disease [4].

In the context of the COVID-19 outbreak, Africa, as with other infectious diseases, was confronted with a weak case detection and surveillance system [5–7]. While developed countries had implemented large-scale screening, in Africa, testing was mainly offered to people with symptoms consistent with COVID-19 and to travelers [8]. Thus, the low number of cases in Africa is more a result of under-diagnosis. This was amplified by the relatively low clinical expression of the COVID-19 cases in Africa, contrary to predictions made early during the pandemic [9]. In addition, certain messages and rumors disseminated on conventional and social media have contributed to the population's mistrust of the reality of the pandemic, which has not encouraged people to be tested and later to be vaccinated against COVID-19 [10,11].

As in other parts of the world, COVID-19 has had a significant impact on various socio-economic conditions in sub-Saharan African (SSA) countries [9]. The use of health services, particularly blood transfusion services, by the population has been affected [12]. There is no evidence of transmission of SARS-CoV-2 through blood transfusion. Nevertheless,

Figure 1. Blood collection aeras of the nine regional blood transfusion centers in Burkina Faso.



WHO has recommended that measures be taken to avoid collecting infected or at-risk individuals as a precautionary measure and to avoid exposing staff and blood donors [13]. These measures include encouraging self-deferral or deferral of probable, suspected, or confirmed cases for at least four weeks or longer, as appropriate. Overall, the COVID-19 pandemic has had a negative impact on blood availability [12,14].

Several seroprevalence studies of SARS-CoV-2 infection have been conducted in many SSA countries [15–18]. Almost all of them revealed a large circulation of the virus within the different populations. In Mali, seroprevalence increased from 12% in September 2020 to 69.8% in May 2021 [18]. In October and November 2021, seroprevalences of 42.5% and 53.5% were noted in Nigerian urban and rural areas respectively [15]. In Ghana, Madagascar, and Burkina Faso, seroprevalences reached approximately 41.2%, 41.5% and 55.7%, respectively [17]. Studies conducted among healthy blood donors revealed such a trend [19,20]. Indeed, from September 2021 to April 2022, a seroprevalence of 62.7% was found in Cameroonian blood donors [19]. In Malawi, this seroprevalence increased from 18.5% in October 2020 to 64.9% in May 2021 [20].

In Burkina Faso, several studies on the prevalence of SARS-CoV-2 antibodies have been conducted [16,17,21]. However, the data published so far are quite disparate. They have focused either on limited geographical areas [17] or on specific groups (health workers, HIV-infected individuals) [16,21]. Therefore, this seroprevalence survey IgM/IgG antibodies against SARS-CoV-2 in healthy blood donors was conducted to assess the reality of SARS-CoV-2 infection in the general population in Burkina Faso.

Methodology

Study setting and design

It was a cross-sectional study consisting of SARS-CoV-2 antibodies screening among healthy blood donors from March to April 2022 in nine regional blood transfusion centers (RBTC) affiliated with the National blood transfusion center (NBTS) of Burkina Faso (Figure 1).

Burkina Faso reported its first cases of COVID-19 in early March 2020 in Ouagadougou. Bobo-Dioulasso and other regions of the country were gradually affected. Several waves have been recorded, including the Omicron wave in early 2022 [22]. But as in most SSA countries, health facilities have never been overwhelmed by patients, as has been the case in some European countries and the United States. As of the end of April 2022, a cumulative total number of 20,929 confirmed cases and 385 deaths have been recorded nationwide [23]. Vaccination against COVID-19 was introduced on June 2, 2021, for people over 18 years old, before being extended to those aged 12 to 18 at the end of 2021. At the time of this study sample collection, 2.53 million people had received at least one dose, i.e., 11.9% of the population and 1.6 million (7.2%) had received the full vaccination schedule. The coverage areas of the Gaoua, Ouahigouya, Kaya, Fada N'Gourma and Tenkodogo RBTCs each had fewer than 200,000 people vaccinated, those of Dédougou and Ouagadougou between 200,000 and 300,000, and those of Koudougou and Bobo-Dioulasso just over 400,000 individuals [23].

Study participants and sample size

The study included individuals accepted for whole blood donation in one of the nine blood centers during the study. In Burkina Faso, blood donation candidates undergo medical pre-donation screening using a standardized questionnaire. The standard selection criteria were designed to identify risk factors for HIV, HBV, HCV, and syphilis, as well as medical contraindications to blood donation. During the COVID-19 pandemic, additional criteria were applied to identify influenza-like symptoms within 28 days prior to donation and situations of close contact with suspected or confirmed COVID-19 cases, as recommended by WHO [13]. Donors of both sexes (male/female), between the ages of 18 and 60, with no risk factors for HIV, viral hepatitis B and C, syphilis, or any current or recent infectious or chronic disease, are accepted for blood donation.

Assuming a defined population (N) of approximately 150,000 blood donors, a hypothetical seroprevalence (p) of 50%, an absolute error (e) of 2%, an alpha (α) of 5%, and Z_α of 1.96, the study sample was estimated at 2,364 blood donors using the formula below [24]:

$$x = \frac{\mathrm{Np}\,(1-\mathrm{p})}{\left[\frac{e^2}{Z^2_{1-\frac{\alpha}{2}}}\,(\mathrm{N}-1) + \mathrm{p}\,(1-\mathrm{p})\right]}$$

This sample was divided between the blood transfusion centers in proportion to the number of blood donations they collect each year.

Data collection and serological analysis for SARS-CoV-2 antibodies

Data concerning donors' sociodemographic characteristics (age, sex, residence), ABO/RhD blood group, and serological status (HIV, HCV, HBV, and syphilis) were collected from blood centers' databases. Blood samples taken at the time of blood collection for the mandatory blood unit release tests were used for SARS-CoV-2 antibodies testing. The samples were stored in a monitored-temperature refrigerator at 2-8 °C until testing was performed, within a maximum of 3 days. The rapid diagnostic tests (RDT) COVID-19 IgM/IgG Rapid test Cassette® kit, Lot N° 2008293, Ref: GCCOV-402a (Zhejiang Orient Gene Biotech CO., Ltd; Zhejiang, China) were used. The COVID-19 IgM/IgG Rapid test is approved by the European Union (CE mark) and the Chinese National Medical Products Administration. The Food and Drugs administration issued an emergency use authorization (EUA) on 29 May 2020.

Briefly, the test uses the principle of lateral flow immunochromatography to produce a qualitative result based on the appearance or not of a red colour on the IgM or IgG line or both. Indeed, the test consists of a two-well cassette, one for the patient's biological sample (whole blood/serum/plasma) and one for the buffer solution. The sample well contains recombinant SARS-CoV-2 antigens consisting of the receptor-binding domain (RBD) of spike protein bound in nitrocellulose with human anti-IgM antibodies (IgM test line), human anti-IgG antibodies (IgG test line) and rabbit anti-IgG antibodies (C control line) and coated with a colorimetric conjugate that changes colour with the buffer. The intrinsic performance of the assays claimed by the manufacturer, based on tests performed on whole blood from symptomatic patients with positive RT-PCR and convalescent patients, was a sensitivity of 87.9% (for IgM) / 97.2% (for IgG) and a specificity of 100% for IgG and IgM [25].

Quality control and assurance

Tests were performed and the results interpreted as per as manufacturer's instructions [25] by trained technicians and medical biologists. A performance evaluation of the COVID-19 IgM/IgG Rapid test Cassette® kit in comparison (gold-standard) with WANTAI SARS-CoV-2 Ab ELISA® kit (Beijing Wantai biological and pharmacy Enterprise co, Ltd, Beijing, China) on the "Elisys Uno" automated machine (Human, Germany) has been conducted in Burkina Faso, prior to the introduction of COVID-19 vaccination. The WANTAI SARS-CoV-2 Ab ELISA is a CE mark and FDA's EUA sandwich enzyme immunoassay with a recombinant RBD of SARS-CoV-2 spike protein, that is intended for qualitative detection of total antibodies (including IgG and IgM) in human serum and plasma. After classifying the RDT results as True/False positive and True/False negative on the basis of the ELISA results, the performance calculations showed a sensitivity/specificity of 51.6% / 97.4%, positive/negative predictive values (PPV/NPV) of 95.3% / 66.8% and an accuracy of 74.5% [26]. These performance values were then used to adjust the prevalence of total anti-SARS-CoV-2 antibodies using the following formula [27]:

$P_{Adjusted} = P_{Crude} \times PPV + (1 - P_{Crude}) \times (1 - NPV)$, with $P_{Adjusted}$ and P_{Crude} as adjusted and crude prevalence, PPV and NPV as positive predictive value and negative predictive value respectively.

Statistical analysis

The data collected were entered on an Epi-Info 7.2.5.0 (CDC, Atlanta, GA, USA) and exported into STATA/SE version 15.1 (College Station, TX: StataCorp LLC) for analysis. Donor age was classified into four categories: under 20, 20-29, 30-39, and over 40. The regional capitals, the cities where the blood centers are located, were considered urban areas. The other locations were classified as rural areas. Frequencies and proportions were used to describe categorical variables and mean with standard deviation for quantitative variables. Chi-square and odds ratio were used in univariate analysis and multivariable logistic regression to compare SARS-CoV-2 antibodies between different groups according to donors and blood donation characteristics at the significant threshold $p < 0.05$.

Table 1. Baseline characteristics of the blood donors included in the study, Burkina Faso, April 2022 (n = 3,084).

Characteristics	n	%
Sex		
Male	1,809	58.7
Female	1,275	41.3
Age group (years)		
< 20	788	25.6
20 – 29	1,979	64.2
30 – 39	223	7.2
40 and over	94	3.0
Residence		
Urban	1,845	59.8
Rural	1,239	40.2
Blood centre		
Bobo – Dioulasso	493	16.0
Dédougou	201	6.5
Fada N'Gourma	298	9.7
Gaoua	250	8.1
Kaya	220	7.1
Koudougou	296	9.6
Ouagadougou	826	26.8
Ouahigouya	249	8.1
Tenkodogo	251	8.1
Blood collection sites		
Mobile collection	2,548	82.6
Fixed site	536	17.4
Overall	**3,084**	**100**

Ethical considerations

The Health Research Ethics Board approved the study (Decision No. 2022-04-089). Each study participant provided written informed consent prior to enrolling in the study. The anonymity and confidentiality of study participants' information were respected.

Results

A total of 3,084 healthy voluntary and unpaid blood donors, including 58.7% male donors were enrolled. Donor age ranged from 18 to 67 years, with an average of 22.9 ± 5.8 years; donors aged 20 to 29 years accounted for 64.2%. Blood donors from urban areas represented 59.8% and 82.6% donated blood at mobile collections (Table 1). A total of 2,684 sera tested positive for SARS-CoV-2 antibodies, giving an overall crude seroprevalence of 87.0%. After adjustment for test kit sensitivity and specificity, overall seroprevalence was 87.2 (95% CI 86.4– 87.9) (Table 2). The prevalence of SARS-CoV-2 antibodies was quite similar in men and women (87.3 vs. 87.1%; $p = 0.845$) and in urban and rural areas (87.3 vs. 87.1%; $p = 0.785$) in univariate analysis. Blood donors aged 40 years or older were more affected ($p = 0.000$) (Table 2).

As shown in Table 2, SARS-CoV-2 antibodies were more common in blood group AB (89.3%) than in the other blood groups ($p = 0.084$). There was also no difference based on the presence or absence of D antigen ($p = 0.081$).

In multivariable logistic regression analysis, donors aged 30-39 years had 0.5 (95% CI: 0.3-0.8) fold lower odds of having SARS-CoV-2 antibodies compared to those under 20 years. Similarly, compared to Bobo-Dioulasso, having donated blood at the Dédougou, Fada N'Gourma, and Koudougou blood centers had 0.5 (95% CI: 0.3-0.8), 0.2 (95% CI: 0.1-0.3), and 0.5 (95% CI: 0.3-0.8) fold lower odds of having SARS-CoV-2 antibodies, respectively. However, donors from the Ouagadougou blood centre were twice as likely to have antibodies (OR = 2.2; 95% CI (1.3-3.3), $p = 0.001$). ABO and RH blood groups were not associated with SARS-CoV-2 antibody positivity (Table 2).

Discussion

The objective of this study was to determine the prevalence of IgM/IgG antibodies against SARS-CoV-2 in blood donors. Of the 3,084 healthy blood donors screened using RDT, an overall crude seropositivity

(IgG and IgM antibodies) of 87.0% and an adjusted seroprevalence of 87.2% (after adjustment to RDT sensitivity and specificity). Donor age and blood center location were the factors associated with SARS-CoV-2 antibody seropositivity.

This is one of the main studies that have assessed the seroprevalence of SARS-CoV-2 antibodies in Burkina Faso, because of its large sample size and the number and geographic dispersion of the localities involved. However, it did not cover all administrative regions of the country and included only blood donors, a selected population that did not include persons under 18 and over 65. In addition, at the time of the study, COVID-19 vaccines had already been introduced in Burkina Faso for almost a year (on June 2, 2021). Therefore, anti-SARS-CoV-2 antibodies resulting from vaccination in some individuals may have biased the study results, given that the test used did not allow natural antibodies to be distinguished from post-vaccination antibodies. However, the impact of these post-vaccination antibodies could be relatively marginal, given the low level of public interest in vaccination. Only people who had to travel felt the need to be vaccinated to meet the requirements of the destination countries. At the time of this study, only 11.9% of the population had received at least one dose of vaccine [23]. The RDTs used are described as having technical limitations related to the possibility of cross-reactions, poor technical operation (handling or interpretation errors), or lack of sensitivity (presence of inhibitors or antibody degradation) leading to false positive or negative results [28]. Nevertheless, the determination of overall antibody carriage in blood donors provides an indication of the extent of exposure to the virus in the general population.

The overall adjusted seroprevalence of 87.2% with a large majority of IgG antibodies, shows that SARS-CoV-2 was widely circulating in the population of the study areas. Thus, official data reporting a cumulative number of 20,929 confirmed [23] appear to be underestimated. This high seroprevalence is consistent with the population's perception and attitudes toward measures to prevent SARS-CoV-2 transmission [29]. Moreover, this high seroprevalence is detected in a context of low population adherence to COVID-19 vaccination and after the wave of the Omicron variant [22], which has been described as more contagious (10 times more than the original strain and 2 times more than the Delta variant [30]). Indeed, the response to COVID-19 in Burkina Faso has been marked by

Table 2. Crude and adjusted prevalence of anti-SARS-CoV-2 antibodies and associated factors in univariate and multivariable logistic regression analysis in Burkina Faso, April 2022.

Characteristics	n	% positivity to SARS-CoV-2 antibodies (95% CI)		Univariate analysis		Multivariable logistic regression	
		Crude prevalence	Adjusted prevalence	OR (95% CI)	p	OR (95% CI)	*p*
Overall	**3,084**	**87.0 (85.7 – 88.1)**	**87.2 (86.4– 87.9)**	-	-	-	-
Sex							
Male	1,809	87.1 (85.4 – 88.5)	87.3 (86.2– 88.1)	Ref.	-	Ref.	
Female	1,275	86.8 (84.8 – 88.6)	87.1 (85.9– 88.2)	1.0 (0.8 - 1.2)	0.845	1.0 (0.8 – 1.3)	0.968
Age group (years)							
< 20	788	88.3 (85.9 – 90.4)	88.0 (86.5– 89.3)	Ref.		Ref.	
20 – 29	1,979	86.3 (84.8 – 87.8)	86.8 (85.9– 87.7)	0.8 (0.6 – 1.1)	0.166	0.9 (0.7 – 1.1)	0.324
30 – 39	223	84.7 (79.4 – 88.9)	85.8 (82.5– 88.4)	0.7 (0.5 – 1.1)	0.155	0.5 (0.3 – 0.8)	0.007
40 and over	94	86.4 (85.1 – 87.5)	86.8 (86.0– 87.5)	1.9 (0.6 – 4.6	0.129	1.7 (0.7 – 4.3)	0.215
Residence							
Urban	1,845	87.1 (85.5 – 88.5)	87.3 (86.3– 88.1)	Ref.		Ref.	
Rural	1,239	86.8 (84.7 – 88.5)	87.1 (85.8– 88.1)	1.0 (0.8 – 1.2)	0.785	0.9 (0.6 – 1.1)	0.318
Blood centre							
Bobo – Dioulasso	493	89.6 (86.6 – 92.0)	88.8 (87.0– 90.3)	Ref.		Ref.	
Dédougou	201	81.6 (75.6 – 86.4)	83.9 (80.1– 86.8)	0.5 (0.3 – 0.8)	0.004	0.5 (0.3 – 0.8)	0.007
Fada N'Gourma	298	63.8 (58.1 – 69.0)	72.8 (69.3– 76.0)	0.2 (0.1 – 0.3)	0.000	0.2 (0.1 – 0.3)	0.000
Gaoua	250	87.6 (82.9 – 91.1)	87.6 (84.7– 89.8)	0.8 (0.5 – 1.3)	0.399	0.8 (0.5 – 1.3)	0.444
Kaya	220	87.3 (82.2 – 91.1)	87.4 (84.2– 89.8)	0.8 (0.5 – 1.3)	0.350	0.7 (0.4 – 1.2)	0.178
Koudougou	296	82.1 (77.3 – 86.1)	84.2 (81.2– 86.7)	0.5 (0.3 – 0.8)	0.003	0.5 (0.3 – 0.8)	0.002
Ouagadougou	826	95.0 (93.3 – 96.3)	92.2 (91.1– 93.0)	2.2 (1.4 – 3.4)	0.000	2.1 (1.3 – 3.3)	0.001
Ouahigouya	249	90.0 (85.5 – 93.1)	89.1 (86.3 – 91.0)	1.0 (0.6 – 1.7)	0.897	1.1 (0.7 – 1.9)	0.686
Tenkodogo	251	88.8 (84.3 – 92.2)	88.3 (85.5– 90.4)	0.9 (0.6 – 1.5)	0.734	0.9 (0.5 – 1.5)	0.693
ABO blood group							
A	700	88.9 (86.3 – 91.0)	88.4 (86.8 – 89.7)	Ref.		Ref.	
B	853	87.2 (84.8 – 89.3)	87.3 (85.9– 88.6)	0.8 (0.6 – 1.2)	0.325	0.8 (0.6 – 1.2)	0.306
O	1,375	85.4 (83.5 – 87.2)	86.2 (85.0– 87.3)	0.7 (0.6 – 1)	0.032	0.8 (0.6 – 1.0)	0.068
AB	156	90.4 (84.6 – 94.1)	89.3 (85.7– 91.6)	1.2 (0.7 – 2.1)	0.580	1.2 (0.6 – 2.2)	0.582
RhD antigen							
Negative	233	83.3 (77.9 – 87.5)	84.9 (81.6– 87.5)	Ref.		Ref.	
Positive	2,851	87.3 (86.0 – 88.4)	87.4 (86.6– 88.0)	1.4 (1.0 – 2.0)	0.082	1.3 (0.9 – 1.9)	0.136

controversy, rumors, and misinformation [4]. The reality of the disease has been denied, mocked, and even presented as a disease that only affects the wealthy. This affected the public acceptability of barrier measures and other public health interventions [33].

Studies in other SSA countries, both among blood donors and in other population groups, have shown a similar pattern of the COVID-19 pandemic [15–20]. These high seroprevalences show that even if the apocalyptic predictions (based on the weaknesses of its health systems, the lack of resources to implement adequate protective measures, the promiscuity, and poverty of the populations, etc.) [34] have not been realized, the virus has nevertheless spread among these populations. Suppose the low number of confirmed cases reported in SSA countries is rather explained by the low number of tests performed daily (usually reserved for symptomatic patients and travelers). In that case, it should also be noted that health services have not been particularly overwhelmed by patients presenting signs compatible with COVID-19 [35]. This indicates that there have been more pauci- or asymptomatic forms in SSA than in other continents. Many factors have been suggested to explain this situation. These include the relative youth of the population [35,36], early implementation of protective measures for vulnerable individuals, etc. Another plausible explanation is the cross-reactive immunity due to the other human coronaviruses that have circulated widely in SSA. Indeed, several studies on sera from African subjects collected before the onset of the COVID-19 pandemic show the presence of antibodies cross-reacting with SARS-CoV-2 particles [37–40].

Another major finding is that beyond the two major cities, Ouagadougou located in the central region, and Bobo-Dioulasso in the west, which were the focus of attention at the time of the pandemic, other cities in the country were also affected. Indeed, Gaoua in the southwest, Kaya in the north-central region, Ouahigouya in the north, and Tenkodogo in the central-eastern region had seroprevalences above 87%. Compared to Bobo-Dioulasso, the economic capital and second largest city in the country, there was no significant difference with these secondary cities ($p >$ 0.05). However, seroprevalences in Bobo-Dioulasso (88.8%) were significantly lower than in Ouagadougou (92.2%), but higher than in Fada N'Gourma (72.8%). Overall, there was no significant difference between urban and rural areas (87.3 vs. 87.1%; $p = 0.785$). This indicates that the virus circulates independently of the level of urbanization in Burkina Faso. A nationwide study conducted in Burkina Faso in October 2021, during the Delta wave, among 6,592 individuals aged 5 years and older from 13 administrative regions, also noted a similar spread of the virus in urban and rural areas (unpublished data). Thus, the respect and the effectiveness of the protection measures against COVID-19 are *a priori* the only determining factors of this propagation. During the early stage of the pandemic and in the months that followed, the focus was on the large urban centers (Ouagadougou and Bobo-Dioulasso); rural areas were more neglected, which may have facilitated the spread of the virus. One of the lessons to be learned is that, in such a situation, prevention efforts must also be directed towards rural areas, even if they are less populated. This is especially necessary because access to curative care in these areas is often more difficult for the population [41].

The risk of carrying anti-SARS-CoV-2 antibodies was 50% lower in young adults aged 30 to 39 years (OR = 0.5; 95% CI: 0.3 – 0.8, $p = 0.007$) than in adolescents under 20. Adults aged 40 years and over had 1.7 odds of being anti-SARS-CoV-2 antibody positive without statistical significance compared to youth under 20 years of age. These results differ somewhat from previous data showing an increase in seroprevalence with age. In Kenya, a population-based study reported that individuals aged 20-59 years were at least twice as seropositive as those aged 0-9 years [42]. Immunologic factors, including the type of immune response dominated by the local innate immune response (particularly in the nasopharyngeal mucosa in individuals younger than 15 years of age), have been suggested to explain the low presence of circulating antibodies in children and adolescents [43]. However, it should be noted that the findings of studies are quite divergent on the association between age and seroprevalence. Indeed, some authors also found that the presence of antibodies is higher in school-age children, adolescents, and young adults than in children under five and people over 55 years of age. According to these authors, this observation could be explained by greater exposure of these age groups to the virus, due to frequent human contact in schools and workplaces [44,45].

Although blood group O (86.2%) and D-negative (84.9%) subjects had lower seroprevalences compared to other ABO and RHD blood groups, there was no statistically significant association according to ABO blood group or RH D antigen. The ABO blood group which comprises some carbohydrate epitopes on blood cells and other tissues has been suspected to influence the susceptibility to infectious diseases. The wide distribution in the environment and the polymorphism of these carbohydrate molecules mean that they are suspected of playing a role in the cellular recognition and binding of pathogenic micro-organisms to target cells to trigger infection [46]. Therefore, early in the pandemic, researchers investigated the association between susceptibility to SARS-CoV-2 infection and ABO blood group. But the findings are highly controversial and the mechanisms involved not yet clearly established, so it is difficult to draw definitive conclusions. The results of this study were not consistent with those that advocated a protective character of blood group O over blood groups [46,47].

Conclusions

During the COVID-19 pandemic, SSA countries experienced difficulties in performing diagnostic testing, making the true magnitude of the pandemic unknown. Therefore, population-based sero-epidemiological studies of SARS-CoV-2 antibodies remain the best alternatives for assessing the extent of the epidemic a posteriori. This study is one of the first to include most of the country's administrative regions. Contrary to official reports on the pandemic, the study shows widespread circulation of the virus in the country, in both urban and rural areas. It, therefore, seems necessary that in situations such as the COVID-19 pandemic, prevention efforts should also be deployed in rural areas, which are more often than not poorly equipped with health services and where an outbreak of severe cases could be more catastrophic.

Acknowledgements

The authors thank all the staff of the regional blood transfusions centers.

Corresponding author

Sawadogo Salam
01 BP 865 Ouagadougou 01
Burkina Faso
Email: salam.sawadogo@ujkz.bf;
salemserein@hotmail.com

Conflict of interests

No conflict of interests is declared.

References

1. Cucinotta D, Vanelli M (2020) WHO declares COVID-19 a pandemic. Acta Biomed 91: 157–160. doi: 10.23750/abm.v91i1.9397.
2. WHO (2020) WHO Director-General’s opening remarks at the media briefing on COVID-19 - 11 March 2020. World Health Organization. Available: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020. Accessed: 21 Jan 2023.
3. WHO (2023) WHO Coronavirus (COVID-19) Dashboard. WHO Coronavirus (COVID-19) Dashboard. Available: https://covid19.who.int/. Accessed: 4 Jan 2023.
4. Lopez AD, Mathers CD, Murray CJL (2004) The Global epidemiology of infectious diseases. World Health Organization, Geneva. Available: https://apps.who.int/iris/bitstream/handle/10665/43048/9241592303.pdf?se. Accessed: 4 Jan 2023.
5. Shahrour G, Jaradat D, Dardas LA (2021) Barriers related to COVID-19 testing intention. Public Health Nurs 38: 978–983. doi: 10.1111/phn.12950.
6. Kebede A, Lanyero B, Beyene B, Mandalia ML, Melese D, Girmachew F, Mekonnen A, Ayana G, Yemanebirhan N, Hailu G, Asrat H, Nurahmed N, Gashu A, Eshetu K, Assefa Z, Abayneh A, Musa E, Abate E (2021) Expanding molecular diagnostic capacity for COVID-19 in Ethiopia: operational implications, challenges and lessons learnt. Pan Afr Med J 38: 68. doi: 10.11604/pamj.2021.38.68.27501.
7. Kuster AC, Overgaard HJ (2021) A novel comprehensive metric to assess effectiveness of COVID-19 testing: Inter-country comparison and association with geography, government, and policy response. PLoS ONE 16:e0248176. doi: 10.1371/journal.pone.0248176.
8. WHO (2021) The coronavirus disease 2019 (COVID-19) strategic preparedness and response plan for the WHO African Region (1 February 2021 – 31 January 2022).
9. Lone SA, Ahmad A (2020) COVID-19 pandemic – an African perspective. Emerg Microbes Infect 9: 1300–1308. doi: 10.1080/22221751.2024.2432345.
10. Ahinkorah BO, Ameyaw EK, Hagan JE, Seidu A-A, Schack T (2020) Rising above misinformation or fake news in africa: another strategy to control COVID-19 spread. Front Commun 5: 45. doi: 10.3389/fcomm.2020.00045.
11. Kabakama S, Konje ET, Dinga JN, Kishamawe C, Morhason-Bello I, Hayombe P, Adeyemi O, Chimuka E, Lumu I, Amuasi J, Acheampong T, Dzinamarira T (2022) Commentary on COVID-19 vaccine hesitancy in sub-Saharan Africa. Trop Med Infect Dis 7: 130. doi: 10.3390/tropicalmed7070130.
12. Loua A, Kasilo OMJ, Nikiema JB, Sougou AS, Kniazkov S, Annan EA (2021) Impact of the COVID-19 pandemic on blood supply and demand in the WHO African Region. Vox Sang 116: 774–784. doi: 10.1111/vox.13071.
13. WHO (2021) Guidance on maintaining a safe and adequate blood supply during the coronavirus disease 2019 (COVID-19) pandemic and on the collection of COVID-19 convalescent plasma. Available: https://www.who.int/publications/m/item/who-recommendations-on-sars-and-blood-safety. Accessed: 13 March 2023.
14. Veseli B, Sandner S, Studte S, Clement M (2022) The impact of COVID-19 on blood donations. PLoS ONE 17: e0265171. doi: 10.1371/journal.pone.0265171.

15. Chechet GD, Kwaga JKP, Yahaya J, Noyes H, MacLeod A, Adamson WE (2022) SARS-CoV-2 seroprevalence at urban and rural sites in Kaduna State, Nigeria, during October/November 2021, immediately prior to detection of the Omicron variant. Int J Epidemiol 51: 1361–1370. doi: 10.1093/ije/dyac141.
16. Kribi S, Touré F, Mendes A, Sanou S, Some A, Aminou AM, Belarbi E, Griessel R, Hema A, Kabore F, Pitzinger P, Strydom A, Vietor AC, Traoré K, Zongo A, Anoh EA, Grossegesse M, Hofmann N, Ouangraoua S, Poda A, Kagone T, Schubert G, Eckmanns T, Venter M, Leendertz F, Akoua-Koffi C, Tomczyk S (2022) Multicountry study of SARS-CoV-2 and associated risk factors among healthcare workers in Côte d'Ivoire, Burkina Faso and South Africa. Trans R Soc Trop Med Hyg 117: 179-188. doi: 10.1093/trstmh/trac089.
17. Struck NS, Lorenz E, Deschermeier C, Eibach D, Kettenbeil J, Loag W, Brieger SA, Ginsbach AM, Obirikorang C, Maiga-Ascofare O, Sarkodie YA, Boham EEA, Adu EA, Asare G, Amoako-Adusei A, Yawson A, Boakye AO, Deke J, Almoustapha NS, Adu-Amoah L, Duah IK, Ouedraogo TA, Boudo V, Rushton B, Ehmen C, Fusco D, Gunga L, Benke D, Höppner Y, Rasolojaona ZT, Rasamoelina T, Rakotoarivelo RA, Rakotozandrindrainy R, Coulibaly B, Sié A, Awuah AA-A, Amuasi JH, Souares A, May J (2022) High seroprevalence of SARS-CoV-2 in Burkina-Faso, Ghana and Madagascar in 2021: a population-based study. BMC Public Health 22:1676. doi: 10.1186/s12889-022-13918-y.
18. Alber D, Haidara FC, Luoma J, Adubra L, Ashorn P, Ashorn U, Badji H, Cloutman-Green E, Diallo F, Ihamuotila R, Klein N, Martell O, Onwuchekwa UU, Samaké O, Sow SO, Traore A, Wilson K, Ducker C, Fan Y-M (2022) SARS-CoV-2 infection and antibody seroprevalence in routine surveillance patients, healthcare workers and general population in Kita region, Mali: an observational study 2020–2021. BMJ Open 12: e060367. doi: 10.1136/bmjopen-2021-060367.
19. Medi CI, Voundi EV, Lobe SA, Bille BE, Ngogang MP, Mintya AN, Embolo EL, Essomba EN, Nguedia JA (2022) COVID-19 in blood donors at Laquintinie Hospital in Douala during the third wave: a cross sectional study. Open J Epidemiol 12: 367–379. doi: 10.4236/ojepi.2022.123030.
20. Mandolo J, Msefula J, Henrion MYR, Brown C, Moyo B, Samon A, Moyo-Gwete T, Makhado Z, Ayres F, Motlou T, Mzindle N, Kalata N, Muula AS, Kwatra G, Nsamala N, Likaka A, Mfune T, Moore PL, Mbaya B, French N, Heyderman RS, Swarthout T, Jambo KC (2021) SARS-CoV-2 exposure in Malawian blood donors: an analysis of seroprevalence and variant dynamics between January 2020 and July 2021. BMC Med 19: 303. doi: 10.1186/s12916-021-02187-y.
21. Sagna T, Ouedraogo P, Traore L, Obiri-Yeboah D, Yonli A, Tapsoba A, Tovo F, Sorgho A, Zongo L, Nikiema O, Ilboudo D, Belemgnegre M, Nadembega CW, Ouermi D, Djigma FW, Zohoncon TM, Poaty H, Colizzi V, Simpore J (2022) Enigma of the high prevalence of anti-SARS-CoV-2 antibodies in HIV-positive people with no symptoms of COVID-19 in Burkina Faso. J Public Health Afr 13: 1778. doi: 10.4081/jphia.2022.1778.
22. Sawadogo Y, Galal L, Belarbi E, Zongo A, Schubert G, Leendertz F, Kanteh A, Sesay AK, Erhart A, Bañuls A-L, Tarnagda Z, Godreuil S, Tinto H, Ouedraogo AS (2022) Genomic Epidemiology of SARS-CoV-2 in Western Burkina Faso, West Africa. Viruses 14: 2788. doi: 10.3390/v14122788.
23. Cluster Santé (2022) Health cluster bulletin no. 27. Available: https://reliefweb.int/report/burkina-faso/bulletin-ndeg27-du-cluster-sante-avril-2022. Accessed: 19 Feb 2023.
24. Dean A, Sullivan K, Soe M (2013) OpenEpi: open source epidemiologic statistics for public health. Available: www.OpenEpi.com. Accessed: 1 April 2023.
25. Zheijang Orient Gene Biotech (2020) COVID-19 IgG/IgM Rapid Test Cassette (Whole Blood/Serum/Plasma) Instruction for Use. Shanghai International Holding Corp.
26. Ouedraogo HG, Zoure AA, Compaoré TR, Ky H, Zida S, Zingué D, Ouedraogo O, Soubeiga ST, Sagna T, Dabiré C, Kambiré D, Zongo D, Yonli AT, Nikiema AR, Nezien D, Bansé GC, Bicaba BW, Perier S, Sawadogo C, Yabre Z, Sangare L (2023) Evaluation of ten (10) SARS-CoV-2 rapid serological tests in comparison with WANTAI SARS-CoV-2 ab ELISA in Burkina Faso, West Africa. Virol J 20: 57. doi: 10.1186/s12985-023-02011-4.
27. Sempos CT, Tian L (2021) Adjusting coronavirus prevalence estimates for laboratory test kit error. Am J of Epidemiol 190: 109–115. doi: 10.1093/aje/kwaa174.
28. Mouliou DS, Gourgoulianis KI (2021) False-positive and false-negative COVID-19 cases: respiratory prevention and management strategies, vaccination, and further perspectives. Expert Rev Respir Med 15: 993-1002. doi: 10.1080/17476348.2021.1917389.
29. WHO (2021) Advice for the public on COVID-19. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public. Accessed: 1 Feb 2022.
30. Chen J, Wang R, Gilby NB, Wei G-W (2022) Omicron Variant (B.1.1.529): infectivity, vaccine breakthrough, and antibody resistance. J Chem Inf Model 62: 412–422. doi: 10.1021/acs.jcim.1c01451.
31. Douce S (2020) In Burkina Faso, controversy is growing over the management of the fight against the coronavirus. Le Monde. Available: https://www.lemonde.fr/afrique/article/2020/05/13/au-burkina-faso-la-polemique-enfle-autour-de-la-gestion-de-la-lutte-contre-le-coronavirus_6039580_3212.html. Accessed: 23 Jan 2022. [Article in French].
32. Sory I (2022) The effects of Covid-19 barriers on the perceptions of household waste operators in Ouagadougou (Burkina Faso). L'Espace Politique 44. doi: 10.4000/espacepolitique.10080. [Article in French].
33. Ag Ahmed MA, Ly BA, Millimouno TM, Alami H, Faye CL, Boukary S, Accoe K, Van Damme W, Van De Put W, Criel B, Doumbia S (2020) Willingness to comply with physical distancing measures against COVID-19 in four African countries. BMJ Glob Health 5: e003632. doi: 10.1136/bmjgh-2020-003632.
34. United Nations (2020) Impact of COVID-19 in Africa. 28. Available: https://unsdg.un.org/sites/default/files/2020-05/Policy-brief-Impact-of-COVID-19-in-Africa.pdf. Accessed: 1 April 2023.
35. Wamai R, Hirsch J, Van Damme W, Alnwick D, Bailey R, Hodgins S, Alam U, Anyona M (2021) What could explain the lower COVID-19 burden in Africa despite considerable circulation of the SARS-CoV-2 virus? Int J Environ Res Public Health 18: 8638. doi: 10.3390/ijerph18168638.
36. Ghosh D, Bernstein JA, Mersha TB (2020) COVID-19 pandemic: the African paradox. J Glob Health 10: 020348. doi: 10.7189/jogh.10.020348.

37. Snyman J, Sanders EJ, Ndung'u T (2021) COVID-19 in Africa: preexisting immunity and HIV. AIDS 35: 2391–2393. doi: 10.1097/QAD.0000000000003079.
38. Pedersen J, Koumakpayi IH, Babuadze G, Baz M, Ndiaye O, Faye O, Diagne CT, Dia N, Naghibosadat M, McGeer A, Muberaka S, Moukandja IP, Ndidi S, Tauil CB, Lekana-Douki J-B, Loucoubar C, Faye O, Sall A, Magalhães KG, Weis N, Kozak R, Kobinger GP, Fausther-Bovendo H (2022) Cross-reactive immunity against SARS-CoV-2 N protein in Central and West Africa precedes the COVID-19 pandemic. Sci Rep 12: 12962. doi: 10.1038/s41598-022-17241-9.
39. Namuniina A, Muyanja ES, Biribawa VM, Okech AO, Ssemaganda S, Price MA, Hills N, Nanteza A, Bagaya AS, Weiskopf D, Riou C, Reynolds SJ, Galiwango RM, Redd AD (2023) High proportion of Ugandans with pre-pandemic SARS-CoV-2 cross-reactive CD4+ and CD8+ T-cell responses. PLOS Glob Public Health 3: e0001566. doi: 10.1371/journal.pgph.0001566.
40. Souris M, Tshilolo L, Parzy D, Ingoba LL, Ntoumi F, Kamgaing R, Ndour M, Mbongi D, Phoba B, Tshilolo M-A, Mbungu R, Sosso MS, Fainguem N, Dieye TN, Sylla M, Morand P, Gonzalez J-P (2022) Pre-pandemic cross-reactive immunity against SARS-CoV-2 among Central and West African Populations. Viruses 14: 2259. doi: 10.3390/v14102259.
41. Bonnet E, Beaugé Y, Ba MF, Sidibé S, De Allegri M, Ridde V (2022) Knowledge of COVID-19 and the impact on indigents' access to healthcare in Burkina Faso. Int J Equity Health 21: 150. doi: 10.1186/s12939-022-01778-2.
42. Ngere I, Dawa J, Hunsperger E, Otieno N, Masika M, Amoth P, Makayotto L, Nasimiyu C, Gunn BM, Nyawanda B, Oluga O, Ngunu C, Mirieri H, Gachohi J, Marwanga D, Munywoki PK, Odhiambo D, Alando MD, Breiman RF, Anzala O, Njenga MK, Bulterys M, Herman-Roloff A, Osoro E (2021) High seroprevalence of SARS-CoV-2 but low infection fatality ratio eight months after introduction in Nairobi, Kenya. Int J Infect Dis 112: 25–34. doi: 10.1016/j.ijid.2021.08.062.
43. Gilbert C, Lefeuvre C, Preisser L, Pivert A, Soleti R, Blanchard S, Delneste Y, Ducancelle A, Couez D, Jeannin P (2021) Age-related expression of IFN-λ1 versus IFN-I and beta-defensins in the nasopharynx of SARS-CoV-2-infected individuals. Front Immunol 12: 750279. doi: 10.3389/fimmu.2021.750279.
44. SeyedAlinaghi S, Mehrtak M, MohsseniPour M, Mirzapour P, Barzegary A, Habibi P, Moradmand-Badie B, Afsahi AM, Karimi A, Heydari M, Mehraeen E, Dadras O, Sabatier J-M, Voltarelli F (2021) Genetic susceptibility of COVID-19: a systematic review of current evidence. Eur J Med Res 26: 46. doi: 10.1186/s40001-021-00516-8.
45. Viner RM, Mytton OT, Bonell C, Melendez-Torres G-J, Ward J, Hudson L, Waddington C, Thomas J, Russell S, van der Klis F, Koirala A, Ladhani S, Panovska-Griffiths J, Davies NG, Booy R, Eggo RM (2021) Susceptibility to SARS-CoV-2 infection among children and adolescents compared with adults: a systematic review and meta-analysis. JAMA Pediatr 175: 143-156. doi: 10.1001/jamapediatrics.2020.4573.
46. Pereira E, Felipe S, de Freitas R, Araújo V, Soares P, Ribeiro J, Dos Santos LH, Alves JO, Canabrava N, van Tilburg M, Guedes MI, Ceccatto V (2022) ABO blood group and link to COVID-19: A comprehensive review of the reported associations and their possible underlying mechanisms. Microb Pathog 169: 105658. doi: 10.1016/j.micpath.2022.105658.
47. Hussein AD, Bakr EA, Al-Jumaili MHA (2022) Association between ABO blood groups and the risk of infection with SARS-CoV-2 in Iraq. J Int Med Res 50: 030006052211331. doi: 10.1177/03000605221133147.