



Trend in SARS-CoV-2 Antibodies Seroprevalence in Bukavu Between 2020 and 2023: A Hospital-Based Retrospective Study

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Abstract

Background and aims: COVID-19 is undoubtedly underestimated in the South Kivu region due to the inaccessibility of reference diagnostic tests. In this context, serological tests could help estimate the disease's circulation. This study analyzed the dynamics in the SARS-CoV-2 antibodies seroprevalence in Bukavu, East of the Democratic Republic of Congo.

Methods: The results of SARS-CoV-2 antibody tests performed in 2020 (n=1100), 2021 (n=508), and 2022-2023 (n=246) in 4 clinics in Bukavu underwent analysis. Any subject, regardless of age, gender, and origin, was eligible for voluntary SARS-CoV-2 antibody screening. The screening was performed to determine the immune status for professional reasons or clinical clarification in symptomatic subjects. For this purpose, 4 mL of blood was obtained from an antecubital venipuncture for biological analysis. The data were also collected anonymously and confidentially. These rapid lateral flow immunoassays (Cellex qSARS-CoV-2 immunoglobulin G/M [IgG/IgM], and QuickZen COVID-19 IgM/IgG) detected and differentiated SARS-CoV-2 antibodies in volunteer workers and patients.

Results: Between 2020 and 2023, the seroprevalence of SARS-CoV-2 antibodies (IgG+ and IgM+) increased from 37.9% to 65.4% ($P<0.0001$). Early exposure to SARS-CoV-2 (IgM+/IgG-) increased significantly from 5.1% in 2020 to 11.4% in 2021, while it decreased significantly from 11.4% in 2021 to 4.5% in 2022-2023 ($P<0.0001$). Full immunization (IgM-/IgG+) increased from 2.5% in 2020 to 34.1% in 2022-2023. Age between 40 and 59 years (adjusted OR [95% CI]: 1.6 [1.3-2.1], $P<0.0001$) and ≥ 60 years (adjusted OR [95% CI]: 1.6 [1.2-2.1], $P=0.001$), as well as exposure periods 2021 (adjusted OR [95% CI]: 2.0 [1.6-2.5], $P<0.0001$) and especially 2022-2023 (adjusted OR [95% CI]: 3.4 [2.5-4.7], $P<0.0001$) remained independent predictors of SARS-CoV-2 antibody seroprevalence.

Conclusion: The findings of the present study demonstrated extremely high exposure to SARS-CoV-2 and full immunization of a significant proportion of the screened subjects. These results would explain the marginalization of new waves of COVID-19 in Bukavu despite low access to vaccination.

Keywords: Trend, Seroprevalence, SARS-CoV-2, Bukavu

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Introduction

COVID-19 was first reported in Wuhan, China, in December 2019.¹ Since then, its spread has accelerated worldwide, affecting 180 countries or regions. As a result, on March 11, 2020, the World Health Organization (WHO) officially declared it a pandemic, making it a global public health problem.²

As of 26 March 2023, 761 million cases have been confirmed, including 6.8 million deaths.³ However, there is a disparity between different regions of the world. Indeed, while the Western world is currently experiencing a tenth wave of COVID-19, mainly due to post-vaccination immune escape of new variants,^{4,5} Africa is timidly moving into its fifth wave despite low vaccination coverage and non-adherence to preventive measures by its population due to a low socio-economic level.⁶ Moreover, thanks to its young people and possible cross-immunity

between SARS-CoV-2 and other infectious agents,⁷ the sub-Saharan African region (SSA) has a low number of cases of COVID-19 and, above all, a meager mortality rate compared to other areas of the world.³ Similarly, the African continent is distinguished from different regions of the world by its high number of asymptomatic cases (over 67%) and infected patients (over 65%) according to the WHO. This particular epidemiological profile of COVID-19 in SSA calls for regular serological testing to estimate the trend in the seroprevalence of SARS-CoV-2 antibodies in this part of the world.

In Bukavu, eastern Democratic Republic of Congo, the first confirmed cases of COVID-19 were reported in April 2020. The disease has evolved timidly. By September 2022, 3999 confirmed cases had been recorded, including 165 deaths (4.1%). Since then, COVID-19 cases have hardly been reported despite the extremely low level of

vaccination (<1%) in the general population (South Kivu Provincial Health Division). Nonetheless, in this city, we found a cumulative seroprevalence of anti-SARS-CoV-2 immunoglobulin G (IgG) antibodies of 35.2% from May to August 2020 among travelers during the first wave of COVID-19.⁸

This suggests the development of community immunity and, as a result, a significant increase in the seroprevalence of SARS-CoV-2 antibodies. Thus, this updated study investigated the dynamics in the seroprevalence of Bukavu's SARS-CoV-2 antibodies between 2020 and 2023 to test this hypothesis.

Materials and Methods

Studied population

This study took place in Bukavu, in the east of the Democratic Republic of Congo (Figure 1). The city covers an area of 60 km² with a population of over 1 190 000 people (19 833 inhabitants/km²). We retrospectively collected the test results of SARS-CoV-2 antibodies performed between May 2020 and March 2023 in four clinics in Bukavu, namely, Cliniques Universitaires de Bukavu, Clinique Saint Luc de Bukavu, Centre Hospitalier Biopharm, and Centre Hospitalier SkyBorn. Regardless of age, gender, and origin, any subject was eligible for voluntary SARS-CoV-2 antibody screening. The screening aimed to determine the immune status for professional reasons or clinical clarification in symptomatic subjects. To this end, 4 mL of blood was obtained from an antecubital venipuncture for biological analysis.

Biological Analysis

For this purpose, 3 mL of blood was obtained from

an antecubital venipuncture from each subject. After centrifugation, the serum was used for qualitative detection and differentiation of SARS-CoV-2 IgM and IgG antibodies by the Cellex qSARS-CoV-2 IgG/IgM (Cellex, Inc., USA) or QuickZen COVID-19 IgM/IgG (ZenTech s.a, Belgium) lateral flow immunoassay rapid tests depending on the clinics. The sensitivity and specificity were 93.8%-100.0% and 96.0%-99.0%, respectively. No cross-reactions were observed with these tests. These tests have been approved by the Food and Drug Administration (<http://www.cellexcovid.com>) and the Microbiology Laboratory of CHU Liège (<https://www.zentech.be/en/>), respectively.

Operational Definitions

In this study, SARS-CoV-2 seropositive subjects were those in whom IgG and IgM SARS-CoV-2 antibodies were detected. The isolated presence of IgM indicated recent exposure to SARS-CoV-2 between 3 and 6 days, and the IgG + /IgM Company reported full immunization.^{9,10}

Statistical Analyses

MedCalc® software (version 18.11) was used for statistical analyses. The distribution of the variables was tested for normality using the Kolmogorov-Smirnov test. Thus, as appropriate, the data were presented by the median (interquartile range) or the relative frequency in percent. The non-parametric Kruskal-Wallis test was utilized to compare several medians.

The chi-square test was applied to compare categorical variables. The adjustment Chi-square, independence chi-square, and chi-square trend tests were employed for a single measurement variable, two measurement variables, and between several percentages, respectively.



Figure 1. Map of Bukavu, in the East of the Democratic Republic of Congo

The probability of SARS-CoV-2 antibodies' seroprevalence as a function of assumed risk factors was modeled in multiple logistic regression. The independent variables included at the outset were those for which the association with the dependent variable was sufficiently strong ($P \leq 0.020$), and a $P < 0.05$ defined the threshold of statistical significance.

Results

General Characteristics

Table 1 presents the general characteristics of the studied subjects. Between 2020 and 2023, 1854, 508 (27.4%), and 246 (13.3%) SARS-CoV-2 antibody tests were conducted in four clinics in Bukavu, 1100 (59.3%) in 2020, 2021, and 2022-2023, respectively.

In the whole group, the median age was 40.0 (29.0-52.0) years. In addition, 248 (15.4%) subjects were over or under 60, and 1125 (60.7%) of them were males.

SARS-CoV-2 Antibody Seroprevalence

Table 2 provides the seroprevalence of SARS-CoV-2 antibodies. Between 2020 and 2023, the trend was for an increase in SARS-CoV-2 antibody seroprevalence from 37.9% in 2020 to 56.7% in 2021 and 65.4% in 2022-2023. Similarly, the proportion of fully immunized subjects increased from 2.5% in 2020 to 22.8% in 2021 and 34.1% in 2022-2023 ($P < 0.0001$).

In univariate logistic regression (Table 3), compared to subjects < 40 years of age, subjects between 40 and 59 years of age and those 60 years of age and older had 1.6 times more frequent SARS-CoV-2 antibodies, respectively ($P < 0.0001$). Similarly, the SARS-CoV-2 antibody's seroprevalence was 2.0 and 3.4 times more frequent in 2021 and 2022-2023, respectively, compared to 2020

($P < 0.0001$). The difference was not significant between men and women ($P = 0.34$).

In the multivariate analysis, age > 40 years remained the independent predictor of seroprevalence of SARS-CoV-2 antibodies after adjustment for the exposure period ($P < 0.001$, Table 3).

Discussion

This study is the first one to analyze the dynamic in the seroprevalence of SARS-CoV-2 antibodies between 2020 and 2023 in Bukavu. The results showed a significant increase in this seroprevalence from 37.9% to 65.4%.

Our findings corroborate those of other authors. Indeed, the 2020 studies demonstrated low seroprevalences of SARS-CoV-2 antibodies between 0.37% and 22.1%.¹¹ Moreover, Rostami et al, in a meta-analysis, estimated a global seroprevalence of SARS-CoV-2 antibodies of 3.38% (3.05-3.72).¹² In 2021, an update by the same researchers revealed that the worldwide seroprevalence was 9.47% (8.99-9.95),¹³ indicating an increase of 180%.

The increase in the global prevalence of COVID-19 is linked to the emergence of the Beta and Delta variants and their sub-variants.³

Singularly, all meta-analyses represented that SSA is the region with the highest seroprevalence of SARS-CoV-2 antibodies.¹¹⁻¹³ Furthermore, as of April 2022, according to the WHO, up to 65% of Africans have been infected with SARS-CoV-2. All these results corroborate with those of the present study, showing an increase in the seroprevalence of SARS-CoV-2 antibodies from 37.9% to 65.4% among those screened in Bukavu, eastern DR Congo.

The very high exposure to SARS-CoV-2 in most sub-Saharan African countries is related to poor adherence to prevention measures by its population due to a low

Table 1. General Characteristics of Screened Subjects

	Total	2020	2021	2022-2023	P Value
Numbers, n (%)	1.854 (100)	1.100 (59.3)	508 (27.4)	246 (13.3)	<0.0001
Age (y), median (IQR)*	40.0 (29.0-52.0)	39.0 (30.0-51.0)	42.0 (32.0-55.2)	35.5 (25.0-54.0)	0.0007
<40, n (%)	791 (49.2)	445 (50.1)	210 (42.6)	136 (60.2)	
40-59, n (%)	568 (35.3)	331 (37.3)	185 (37.5)	52 (23.0)	<0.0001
≥60, n (%)	248 (15.4)	112 (12.6)	98 (19.9)	38 (16.8)	
Gender					
Male, n (%)	1.125 (60.7)	680 (61.8)	299 (58.9)	146 (59.3)	0.43
Female, n (%)	729 (39.3)	420 (38.2)	209 (41.1)	100 (40.7)	

Note. IQR, Interquartile range.

Table 2. Seroprevalence of SARS-CoV-2 Antibodies in Screened Subjects

	Total	2020	2021	2022-2023	P Value for Trend
SARS-CoV-2 positive, n (%)	866 (46.7)	417 (37.9)	288 (56.7)	161 (65.4)	<0.0001
IgM+, n (%)	639 (34.5)	390 (35.5)	172 (33.9)	77 (31.3)	0.020
IgG+, n (%)	741 (40.0)	361 (32.8)	230 (45.3)	150 (61.0)	<0.0001
IgM+/IgG-	125 (6.7)	56 (5.1)	58 (11.4)	11 (4.5)	<0.0001
IgM-/IgG+, n (%)	227 (12.2)	27 (2.5)	116 (22.8)	84 (34.1)	<0.0001

Note. IgM: Immunoglobulin M.

Table 3. Odd Ratio of seroprevalence of SARS-CoV-2 Antibodies by Supposed Risk Factors

	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P Value
Age categories (y)				
<40	1		1	
40-59	1.5 (1.2-1.9)	0.0001	1.6 (1.3-2.1)	<0.0001
≥60	1.6 (1.2-2.2)	0.0004	1.6 (1.2-2.1)	0.001
Period (y)				
2020	1		1	
2021	2.1 (1.7-2.6)	<0.0001	2.0 (1.6-2.5)	<0.0001
2022-2023	3.1 (2.3-4.1)	<0.0001	3.4 (2.5-4.7)	<0.0001
Gender				
Female	1		1	
Male	0.86 (0.71-1.03)	0.11	0.90 (0.73-1.11)	0.34

Note. OR: Odds ratio; CI: Confidence interval.

socio-economic level.⁶ In addition, with usually low numbers of new infections, several African countries generally relax key control measures for COVID-19, including surveillance and quarantine, as well as public health measures, including masking and banning mass gatherings. Finally, possible cross-immunity between SARS-CoV-2 and other infectious agents could explain this high seroprevalence.⁷

In this study, age was the primary determinant of exposure to SARS-CoV-2, and the most affected age group was 60 years and older. These results conform to those of other researchers. Indeed, elderly subjects are vulnerable due to a higher expression of the angiotensin 2 converting enzyme by target cells than younger age groups.¹⁴ Further, they generally have other comorbidities such as diabetes mellitus, cardiovascular disease, cancer, and the like, which are responsible for the severe forms of the disease, thus prompting them to consult a doctor and be screened. On the other hand, young people are more active and, therefore, more exposed to COVID-19. However, they are primarily asymptomatic; hence very few are screened for this purpose.

Finally, this significant increase in the seroprevalence of SARS-CoV-2 antibodies in Bukavu could suggest the acquisition of community immunity, which explains the marginalization of the new waves.

However, the results of the present study must be interpreted considering their significant limitations. Indeed, by screening in a hospital setting, the results are subject to a selection bias and do not provide the seroprevalence of SARS-CoV-2 antibodies in the general population. Epidemiological studies in the general population show relatively lower SARS-CoV-2 seroprevalences¹¹⁻¹³ than hospital studies.⁸ However, the WHO points out that more than 68% of African subjects were in contact with SARS-CoV-2.⁸ This observation is in line with our results.

In addition, some individuals may have undetectable antibody levels by the rapid serological tests used or may

be seronegative despite exposure to SARS-CoV-2, thus underestimating seroprevalence.

The more effective enzyme-linked immunosorbent assay would have enabled the antibodies present in the subject's blood to be quantified. This technique was not used in this study.

Conclusion

The findings demonstrated a trend in the significant increase in the seroprevalence of SARS-CoV-2 antibodies among subjects screened between 2020 and 2023 in Bukavu, suggesting massive exposure to SARS-CoV-2 and thus the likely acquisition of community immunity in this region. These results could explain the current epidemiological profile of COVID-19 in this city. A serological study in the general population would verify the results of this study.

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Competing Interests

The authors declare no conflict of interests.

Ethical Approval

The data were gathered anonymously and confidentially. The privacy and personalities of patients have been preserved according to the Helsinki Declaration.

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