



# **SARS-CoV-2 Seroprevalence in Healthcare Workers from the Three Teaching Hospitals in Abidjan (Cote D'ivoire) during Pandemic Waves of 2022**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors DSR and KMAA conceptualized and designed the study. Authors ATH and KYM managed respectively the methodological part and occupational health aspects. Authors DSR and SKL drafted the manuscript. Authors DSR, SKL, YOR and AAH critically reviewed it and contributed to its design. Data collection and the assay technique were carried out by authors YOR, AAH, KAPV, SYJ, MS and OD. Author KNA supervised the study from a scientific point of view. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** In view of the concern about the nosocomial character of SARS-CoV-2 known for its high variability and its strong ability to spread, this study was conducted to assess the immunogenicity status through the seroprevalence of COVID -19 among healthcare workers in the three University hospitals of Abidjan (Cocody, Angré, Treichville).

**Methodology:** On a sample of 275 healthcare workers randomly chosen from the different professional strata taking into account the levels of risk intensity of contamination according to services and workstations, we measured total antibodies IgG / IgM and antibodies (neutralizing) anti RBD IgG of SARS-CoV-2 using the following kits respectively: Diagnostics Evolution CHORUS Diesse® Ref 81401 SARS-CoV-2 IgM and 81400 SARS-CoV-2 IgG and Diagnostics Evolution CHORUS Diesse® Ref 81408 SARS- CoV-2 Neutralizing Ab by a technique based on double enzyme fluorescence labeling (ELFA – Enzyme Linked Fluorescence Assay) which combines a two-step sandwich enzyme immunoassay method with fluorescence detection.

**Results:** The predominantly female study population was characterized by young age with rates of vaccination coverage and history of COVID-19 infection, which amount to 65,96% and 50,4% respectively. Among these health agents of which 44.1% and 46.16% worked in a context of intermediate level of risk contamination, considering respectively the department and the workstation, a very strong immunization was noted with a high seroprevalence at 93.5% of the population having produced total antibodies of IgG isotype but no IgM while 6.5% produced both IgG and IgM anti-SARS-CoV-2. Regarding anti-RBD neutralizing antibodies, 99.6% of agents are carriers.

**Conclusion:** This strong immunization is the response both to the vaccine, whose coverage is quite broad, and to the history of contact with the virus circulating in the population. This degree of protection obtained among healthcare workers, can be considered as collective immunity, and should be reassuring.

**Keywords:** Anti-RBD neutralizing antibodies; seroprevalence of COVID-19; healthcare workers; Ivory Coast.

## 1. INTRODUCTION

Since March 2020, when the WHO declared the COVID-19 pandemic, Côte d'Ivoire has notified its first case and despite the social measures put in place, the incidence has rapidly increased to the point of reaching two months later, 2,366 cases with 30 deaths in the country [1]. The healthy environment was not spared. A growing concern has led Médecins Sans Frontières [2] to warn that it is mandatory to prepare for case management and to ensure the protection of healthcare workers. According to the WHO, 19%

of reported infections are among healthcare workers in Europe [3,4,5,6,7]. All clinical and para-clinical health services and administrative and support services are involved.

In Côte d'Ivoire, despite the system of sorting at the entrance of the admission services and the use of epidemiological sheets based on clinical symptoms and the notion of contamination, within the framework of the anti-Covid response, many flaws remained. Concerning clinical signs, many patients were asymptomatic (80%) or only mildly symptomatic, which means that they were

not immediately linked to the disease. As for the notion of contamination, few patients could affirm it.

All these elements contribute to increasing the risk of propagating in health facilities in Côte d'Ivoire, where there is a shortage of healthcare workers [8] already heavily involved in the fight against communicable and non-communicable diseases. Moreover, Covid-19 infection is considered a nosocomial infection that spreads rapidly [4].

And despite the widespread of the virus around the world, there was a difference in the spread of the pandemic among countries affected by the disease [9].

Thus, compared to other continents, very few cases of COVID-19 were reported in subsaharan Africa, and therefore very little quality genomic data are available [10]. There was a so-called "African exception" to the transmission of SARS-CoV-2 in terms of low levels of infection on the continent that required investigations. Faced with this data, the healthcare worker who was both the victim and the vector of this pandemic was in the throes of doubt concerning both the prevalence of the infection, the state of immune protection of the agents and the existence of a psycho-social support. It was therefore legitimate to wonder about the prevalence of the infection and especially its state of immune protection. The objective of this study was to determine the seroprevalence of COVID-19 in healthcare workers in the three teaching hospitals of Abidjan (Cocody, Angré, Treichville).

## 2. MATERIALS AND METHODS

It is an observational and descriptive study from 10/11/2021 to 13/01/2023 which included 275 agents regularly hired and having given their informed consent. These agents were composed of nursing staff (doctors, pharmacists, hospital residents, dental surgeons, senior laboratory technicians in medical biology, nurses, radiology technicians, midwives, orderlies, stretcher bearers), administrative staff. Trainees, staff absent for various reasons at the time of the investigators' visit and all those who refused to participate were not included in the study.

### 2.1 Sampling

The sample size was calculated according to the Schwarz formula:  $N = \frac{z^2 \times P \times (1-P)}{i^2}$  with  $z = 1.96$   $P = 19\%$  (prevalence of infected physicians in Europe [3], no exact data in Côte d'Ivoire)  $Q = 1 -$

$P = 81\%$  and  $i = 5\%$ ,  $N = 237$  people (increased by 15% taking into account those lost to follow-up). This was equal to a total of 275 healthcare workers distributed among the 3 teaching hospitals. The sample for each hospital was drawn taking into account the total number of workers in the hospital.

These workers were distributed according to the level of risk of contamination related to the workstation and the department (Staff at low risk of exposure = no contact with patients ; Staff at high risk of exposure = contact with known COVID-19 patients ; Staff at intermediate risk = contact with patients with unknown or suspected COVID-19 status).

### 2.2 Data Collection Methods and Procedures

The data were collected over 6 months using a validated questionnaire and after three days of prior training of three groups of investigators (6 investigators per group) and one group of investigators per Teaching Hospital. The questionnaire described : Agent Identity (Surname and First Name, Age, gender), Occupational Information (Institution of Origin, Department, Occupational Category, Work Station, Actual Wearing of Personal Protective Equipment (PPE), Background (COVID-19, medical, COVID-19 vaccination).

A sample of 3 ml of serum was obtained after centrifugation (at 5000 rpm for 3mn) 5 ml of venous blood sample from each healthcare worker who has given a written consent. All samples were stored at  $-40^\circ\text{C}$  to the Immunology Laboratory of the Medical Sciences Training and Research Unit of the Felix Houphouët BOIGNY University of Cocody – Abidjan (Ivory Coast).

The anti-SARS-CoV-2 IgM and IgG antibodies were assayed using the following kits, respectively Diagnostics Evolution CHORUS Diesse® Ref 81401 SARS-CoV-2 IgM and 81400 SARS-CoV-2 IgG and Diagnostics Evolution CHORUS Diesse® Ref 81408 SARS-CoV-2 Neutralizing Ab by Enzyme Linked Fluorescence Assay (ELFA) technique.

#### 2.2.1 The assay technique was carried out according to the manufacturer's procedure

#### Interpretation of results:

- $i < 1$  Negative (no anti-SRAS-Cov-2 IgM or IgG detected),

- i 1 Positive (anti-SRAS-Cov-2 IgM or IgG detected).
- When the result is positive, in accordance with the WHO call for harmonisation of serologic tests for SARS-CoV-2, quantification is obtained by converting the SARS-CoV-2 Immunoglobulin Index Units into binding Antibody Units where : 1 index unit = 20.33 BAU/ml according to international standards established by the WHO [11]. A 250 BAU/ml Antibody level defines a low serological response ; A 250 BAU/ml Antibody level defines a strong serological response.

### 2.3 Statistical Analysis

Data were entered on a spreadsheet (Excel 2013) and analyzed by SPSS Version 22.0. Parametric tests (T Student, Anova a factor) for equal variances and nonparametric tests for unequal variances were used for comparison of means. The T Student test was used for qualitative variables with two modalities and the Anova test for variables with more than two modalities. A p-value of 0.05 (bilateral) was considered a statistically significant difference.

### 3. RESULTS

Overall, the results showed that 81.10% of workers relatively wore PPE, 50.4% reported a history of SARS-CoV-2 infection and 65.96% vaccination coverage was noted. The most involved professional groups were Physicians and Surgeons (26.5%), Nurses aides and Nurses respectively 14.2% and 16.7%. They worked in an environment with an intermediate level of risk of contamination. Results concerning the Immunogenicity revealed 99.6% carriers of RBD neutralizing antibodies.

1. Characteristics of the study population (Table 1)
2. Immunogenicity of SARS-CoV-2 in the healthcare workers (Table 2)
3. Professional groups of healthcare workers (Table 3)
4. Immune protection statut according to neutralizing anti RBD antibodies (Table 4).

### 4. DISCUSSION

The coronavirus (COVID-19) pandemic has caused a major health crisis. It has quarantined

half of the world's population. In France, this has led to an urgent reorganization of the healthcare offer. Caregivers were mobilized in such a climate of uncertainty [12]. The rate of spread and especially the lethality of this infection considered nosocomial [3,4,6] has raised a lot of concern among health professionals who were not only at the forefront of the management of acute and chronic diseases, but also they were in insufficient numbers in Côte d'Ivoire. This concern is usually accompanied by an unconventional attitude towards protective tools (vaccination and PPE).

The aim of this work was, firstly to evaluate through seroprevalence, the contact of caregivers with the virus during its circulation, in order to appreciate the epidemiological importance of the infection in the professional health environment.

Then, this study also evaluated the capacity of healthcare workers to respond immunologically both to the infection and to the vaccine in this context of doubt and concern. This could contribute to reassure these essential actors of the health system in Côte d'Ivoire. The general characteristics of the representative sample population (275/2867) from the three university hospitals (Table 1) showed a young adults population (mean age at 39.49 years) who obeyed the general demography of Côte d'Ivoire. The comparison of this study population with the results of 2021 Ivorian population general census showed a slightly older study population [13] with 75.6% under the age of 35. However, there was a female predominance (sex ratio at 1.74) due to certain professions exclusively exercised by women (medical assistant, midwife). Female predominance has been reported by other authors [14,15] for the same reasons. Overall, the study population was overweight (mean BMI 26.27), which represents a risk factor for severity of COVID-19 infection cited elsewhere [16,17]. The relative wearing of PPE was 81.10% (the relative wearing means that one of the following measures is not applied: regular wearing of a mask, regular washing of hands, application of social distancing measures). Absolute wear was 47.29% (strict adherence to all measurements). Indeed, the link between wearing PPE and the rate of contamination was widely reported. This highly contagious virus confers a significant but largely preventable risk to healthcare workers (HCWs) [18]. In some regions, HCWs accounted for up to 11% of all confirmed COVID-19 cases with an increase in reported work-related deaths

[19,20]. Use of PPE could significantly reduce the risk of infection associated with the management of COVID-19 patients [21,22]. While there was little evidence that PPE provides the best protection, donning and removal training, simulation and face-to-face instruction are likely beneficial [23] due to adequacy of training, availability of adjustments and supply limitations [24]. Despite the high risk of contamination linked to the significant migratory movements of the population through public transport which have not been suspended in the country, access to screening has been limited only to the laboratory of the Institut Pasteur in Abidjan. In addition, this laboratory was also the only one authorized for PCR tests on air travel. In these conditions of restricted access to screening, the best marker for assessing the importance of contact with the virus remained the serological test [25]. It detects the presence of immunoglobulins (antibodies), indicating previous exposure to a pathogen or genetically similar family member.

Although seroprevalence is often considered to be an imperfect indicator of immunity and serology does not directly assess a patient's ability to neutralize a pathogen [26], Although seroprevalence is often considered to be an imperfect indicator of immunity and serology does not directly assess a patient's ability to neutralize a pathogen [26], it should be noted that anti-bacterial neutralizing antibodies [26] SARS-CoV-2 are known to be protective.

SARS-CoV-2 is an RNA virus that penetrates the cell by binding itself to the receptor of the angiotensin II conversion enzyme (ACE2), via the binding domain (RBD) of its Spike protein [27,28]. Viral proteins such as RBD of Spike and nucleocapside are highly immunogenic [29] and neutralizing especially anti-RBD [30]. Since genetic material is not always detectable in nasopharyngeal samples, these antibodies can be not only a good screening biomarker but also a proof of the effectiveness of vaccination and post-infectious protection [31]. In our survey, 38.8% reported contracting COVID-19 infection and 71.3% were fully vaccinated (two doses for Pfizer and Astra Zeneca or mixed and one dose for Johnson & Johnson). In terms of total antibodies, 93.5% produced IgG but not IgM while 6.5% produced both anti-SARS-CoV-2 IgG and IgM ; the high rate of healthcare workers who reported a history of infection could be explained by the high migration of the population and the nonrespect of social distancing measures during the peak of the pandemic.

Indeed, all professions were represented (Table 3); among them, practitioners with all clinical specialties and surgeons (26.5), nurses (14.2%), nurse aids (16.17%) were the most representative healthcare workers ; the majority of the agents worked in a context of average level of contamination. They were estimated at 56.76% considering the risk by department and 47.16% according to the workstation (This average level of risk is defined by the notion of contact with patients whose COVID-19 status is unknown). And the high seroprevalence of IgG at 93.5% seemed linked not only to the importance of previous contacts with the virus which has circulated a lot in the population, but also to the drop in vigilance in the application of social preventive measures. Concerning the neutralizing antibodies against RBD, 99.6% (Table 4) of the agents were carriers. These antibodies were in response both to vaccine whose coverage was 71.3% and to the history of COVID-19 infection reported by the health workers. These seroprevalence levels demonstrated the degree of protection achieved among health workers, which could be considered as herd immunity. Indeed, the herd immunity threshold is the minimum proportion of the population that must be immunised against an infectious disease, usually through vaccination, for the incidence of the disease to remain stable or decrease [32,33]. In relation to the infectivity of the agent, for SARS-CoV-2 it is variant-related. For variants under enhanced surveillance, such as B.1.1.7 (Alpha), the threshold is around 80% [34] and it may be higher for newly emerging variants, such as B.1.617.2 (Delta) [35]. Furthermore, the ACE polymorphism could be involved in the process of pathogenicity of COVID-19 [36]. These data highlight the importance of identifying variants in Côte d'Ivoire.

Out of a total source population of 2867 agents from the three Teaching hospitals, a sample of 237 agents to be surveyed, with a 15% increase in the number of those lost to follow-up, was retained. Thus, over the 6-month period, 275 agents gave their informed consent to participate in the survey. This population was divided according to the teaching hospital into 23.3% (ANGRE), 57.5% (COCODY), 13.8% (TREICHVILLE), (Table 1). The population was young adults with an average age of 39.49 years, predominantly female (sex ratio 1.74) and overweight (average BMI 26.27). An average of 81.10% of workers wore PPE relatively (the relative wearing corresponded to one of the

**Table 1. Baseline characteristics of participants population to the survey in the three Abidjan teaching hospitals**

Characteristics	Chu Angre			Chu Cocody			Chu Treichville		
	Number (n)	(%)	Type	Number (n)	(%)	Type	Number (n)	(%)	Type
▪ Number of healthcare workers	69	23,3	-	163	57,5	-	43	13,8	-
▪ Middle age (years)	38,59	-	Young	40,56	-	Young adults	39,32	-	Young
▪ Gender	48/69	70,3	F*	92/163	56,3	F	27/43	63,2	F
▪ BMI**	26,7	-	Overweight	26,45	-	Overweight	25,67	-	Overweight
▪ Wearing PPE***			-						
○ Relative	52/69	81,25		123/163	77,84		32/43	84,21	
○ Absolute	17/69	24,6		40/163	24,5		11/43	25,6	
▪ Medical background	43/112	38,39	HBP°, Diabete, Atopy, sickle cell disease	59/112	52,68	HBP, Diabete, Atopy, sickle cell disease	10/112	8,93	HBP, Diabete, Atopy, sickle cell disease
▪ COVID-19 Vaccination status	53/69	76,8	CVC\$ : 68,9 ICVC\$\$ : 7,9	95/163	58,3	CVC : 49 ICVC: 8,2	27/43	62,8	CVC : 55,9 ICVC: 6,9
▪ COVID-19 Infection status	36 25/69	36,2	YES	108/163	66,3	YES	21/43	48,8	YES
<b>Contamination risk context linked to department</b>									
▪ Low risk	21/69	30,4		22/163	13,5		12/43	28	
▪ Middle risk	24/69	34,8		106/163	65		14/43	32,5	
▪ High risk	24/69	34,8		34/163	20,5		17/43	39,5	
<b>Contamination risk context linked to the workplace</b>									
▪ Low risk	20/69	29		50/163	30,7		5/43	11,6	
▪ Middle risk	27/69	39,1		90/163	55,2		19/43	44,2	
▪ High risk	22/69	31,9		23/163	14,1		19/43	44,2	

\* : Female ; \*\* : Body Mass Index ; \*\*\* : Personal Protective Equipment ; ° : High Blood Pressure ; \$ : Complete Vaccination Coverage ; \$\$ : Incomplete Vaccination Coverage

following measures not applied - wearing a mask - regular hand washing - social distancing measures) and the absolute wearing of PPE was applied by an average of 47.29% (strict compliance with all the measures mentioned above). Concerning the medical history, an average of 33.3% of the agents from the three hospitals had high blood pressure, type II diabetes and an atopic context. While an average of 50.4% claimed to have been infected by SARSCoV-2, 65.96% had been fully vaccinated (two doses for Pfizer, Astra Zeneca or mixed and one dose for Johnson & Johnson). Taking into account the level of risk of contamination linked to service and to the workstation, it was noted that respectively averages of 44.1% and 46.16% of the agents surveyed worked in a context with an intermediate level of risk contamination by SARS- CoV-2. In the 275 healthcare workers, the determination of total IgG and IgM isotype antibodies was carried out in the serum by a technique based on double enzymatic

fluorescence labelling (ELFA - Enzyme Linked Fluorescence Assay) Diagnostics Evolution CHORUS Diesse® Ref 81401 SARS-CoV-2 IgM and 81400 SARS-CoV-2 IgG but not IgM carriers were 257 agents (93.5%). Those carrying both IgG and IgM are 18 (6.5%). The healthcare workers of the three teaching hospitals were divided according to occupation. All occupational strata were represented, taking into account the variable "level of exposure risk" according to Department and Workstation. Medical Doctors of all specialities (Physicians) and surgeons (including dentists) represented 26.5%. Nurses aides and Nurses represented 14.2% and 16.7% respectively. In the 275 healthcare workers, the determination of neutralizing antibodies (anti RBD) was carried out in the serum by a technique based on double fluorescence enzyme labelling (ELFA - Enzyme Linked Fluorescence Assay) Diagnostics Evolution CHORUS Diesse® Ref 81408 SARSCoV-2 Neutralizing Ab. The carriers of RBD neutralizing antibodies were 274/275 (99.6%).

**Table 2. Presence or absence of SARS-CoV-2 total IgG/IgM antibodies in the participants of the survey**

<b>IgG and IgM</b>	<b>Number of healthcare workers (n)</b>	<b>(%)</b>
IgM Negative and IgG Positive	257	93,5
IgM Positive and IgG Positive	18	6,5
<b>Total</b>	<b>275</b>	<b>100,0</b>

**Table 3. Different professional groups of the three university hospital healthcare workers involved in the survey**

<b>Professional groups</b>	<b>Number of healthcare workers (n)</b>	<b>%</b>
Others	12	4,4
Administrative	22	8,0
Cleaners	5	1,8
Medical assistants	9	3,3
Stretcher bearers	10	3,6
<b>Nurse aid</b>	<b>46</b>	<b>16,7</b>
Medical laboratory Technicians	28	10,2
Midwives	22	8,0
<b>Nurses</b>	<b>39</b>	<b>14,2</b>
Pharmaceutical Doctors	10	3,6
<b>Physicians and surgeons</b>	<b>73</b>	<b>26,5</b>
<b>Total</b>	<b>275</b>	<b>100,0</b>

**Table 4. Presence or absence of SARS-CoV-2 neutralizing antibodies in the participants of the survey**

<b>SARS-CoV-2 neutralizing antibodies</b>	<b>Number of healthcare workers (n)</b>	<b>%</b>
Negative	1	0,4
Positive	274	99,6
<b>Total</b>	<b>275</b>	<b>100,0</b>

## 5. CONCLUSION

This high level of immunization was the answer both to the vaccine, whose coverage is fairly broad, and to the history of contact with the virus circulating in the population. This level of protection obtained, which could be considered as a herd immunity, should reassure healthcare workers but also encourage the general population to get vaccinated.

## CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

## ETHICAL CONSIDERATIONS

The study benefited from the agreement of the Medical and Scientific Directorates of the three teaching hospitals by written authorisation and the favourable opinion of the National Committee N° 007-22/MSHPCMU/CNESV-km.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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