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Serological Profile of SARS-CoV-2 IgG Antibodies in Vaccinated and Unvaccinated Hospital Workers in Dakar, Senegal

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Abstract

Background: The COVID-19 pandemic placed hospital workers at the front line of viral exposure, raising critical questions about the magnitude and durability of vaccine-induced humoral immunity in this population. Limited data are available on the serological response to SARS-CoV-2 vaccines among health-care workers in sub-Saharan Africa, particularly in Senegal where the AstraZeneca and Sinopharm vaccines were the main platforms deployed. **Objective:** To assess the serological profile of SARS-CoV-2 IgG antibodies in vaccinated and unvaccinated staff of the Idrissa Pouye General Hospital (HOGIP) in Dakar, Senegal, and to identify epidemiological factors associated with anti-RBD IgG seropositivity. **Methods:** A descriptive and analytical study was conducted from January 2022 to January 2023, enrolling 61 hospital workers (52 vaccinated with at least two doses of the COVID-19 vaccine AstraZeneca or Sinopharm COVID-19 vaccine; 9 unvaccinated controls). Quantitative anti-SARS-CoV-2 IgG antibodies targeting the receptor-binding domain (RBD) of the spike protein were measured by chemiluminescent microparticle immunoassay (CMIA, AdviseDx SARS-CoV-2 IgG II, Abbott) on the ARCHITECT ci4100 analyzer anti-RBD IgG seropositivity was defined as an IgG titer ≥ 50 AU/mL. Non-parametric tests (Mann-Whitney, Kruskal-Wallis, Spearman) were used; $p < 0.05$ was considered significant. **Results:** anti-RBD IgG seropositivity was observed in 98% of vaccinated participants and 100% of unvaccinated participants. Median IgG titers were 4671.8 AU/mL with AstraZeneca, 3177.5 AU/mL with Sinopharm and 1408 AU/mL in unvaccinated controls. Vaccination status ($p < 0.05$) and age (Spearman $\rho = 0.39$, $p = 0.002$) were the

only factors significantly associated with antibody titers. Sex, comorbidities, vaccine type and inter-dose interval had no significant effect. **Conclusion:** Hospital workers at HOGIP showed high humoral immunity to SARS-CoV-2 regardless of vaccination, suggesting widespread occult exposure on top of vaccine-induced responses. Vaccination and age were the main determinants of antibody titers.

Keywords

SARS-CoV-2, IgG Antibodies, Anti-RBD IgG Seropositivity, Vaccination, Hospital Workers

1. Introduction

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has profoundly affected health-care systems worldwide since it was first reported in Wuhan, China, in December 2019 [1]. The World Health Organization (WHO) declared the outbreak a public health emergency of international concern on 30 January 2020 and a pandemic on 11 March 2020 [2]. Senegal reported its first confirmed case on 2 March 2020, becoming one of the first five African countries to detect the virus [3].

Hospital staff have been at heightened risk of exposure throughout the pandemic, raising concerns about transmission within health-care facilities and about the immunological status of front-line workers [4]. Persistence of class G immunoglobulins (IgG) is widely used to identify individuals who have been infected, recovered and possibly developed protective immunity [5]. Quantitative assessment of anti-SARS-CoV-2 IgG therefore plays a key role in seroepidemiological surveillance [6].

To date, the duration of antibody persistence after natural infection or vaccination, and the threshold associated with protection, remain incompletely understood. The Senegalese national vaccination campaign relied mainly on two products: the inactivated whole-virion Sinopharm vaccine (BBIBP-CorV) and the chimpanzee adenovirus-vectored AstraZeneca vaccine (ChAdOx1 nCoV-19), both administered as a two-dose regimen [7] [8]. Few data are available regarding the post-vaccination serological profile of African hospital workers, especially in West Africa. Most published cohorts have been carried out in Europe, North America or Asia, and have predominantly assessed mRNA platforms (BNT162b2, mRNA-1273), which were not deployed in the senegalese national programme at that period. Real-world serological data on Sinopharm and AstraZeneca recipients in sub-Saharan African front-line hospital settings therefore remain scarce, and characterizing humoral responses in this population is still relevant for shaping booster strategies and for documenting hybrid immunity in regions where pre-vaccination seroprevalence was likely substantial.

In this context, we conducted the present study to evaluate the serological pro-

file of SARS-CoV-2 IgG antibodies in vaccinated and unvaccinated staff of the Idrissa Pouye General Hospital (HOGIP) in Dakar, and to identify epidemiological and vaccination-related factors associated with anti-RBD IgG seropositivity.

2. Materials and Methods

2.1. Study Design and Setting

This was a cross-sectional, descriptive and prospective study carried out over a 12-month period, from December 2022 to December 2023, at the Idrissa Pouye General Hospital (HOGIP) in Dakar, Senegal. All technical and administrative units of the hospital (around 500 staff members) were eligible to participate. Participants were recruited on a voluntary basis following an open invitation. Antibody assays were performed at the Medical Biology Laboratory of HOGIP.

2.2. Study Population

Hospital staff who had received at least two doses of a SARS-CoV-2 vaccine, as well as unvaccinated staff acting as controls, were invited to participate. Inclusion criteria were: i) documented receipt of two doses of any anti-COVID-19 vaccine (vaccination card or QR code), or ii) explicit absence of vaccination for the control group. Exclusion criteria were: incomplete vaccination (less than two doses), pregnancy, malignant haematological disorders, known immunodeficiency, current immunosuppressive therapy (including corticosteroids), active infectious disease and withdrawal of consent. Recruitment occurred progressively throughout the study period. A total of 61 participants provided written informed consent and were included in the final analytical sample. Because enrolment relied on voluntary participation over time, the exact number of individuals who actively declined or chose not to participate was not systematically recorded.

2.3. Data Collection

Data were collected using sera from a venous blood sample and a structured case-report form completed in collaboration with the medical, pharmaceutical and paramedical staff of the participating units. Two categories of variables were recorded:

- Epidemiological variables: age, sex, history of SARS-CoV-2 Polymerase Chain Reaction (PCR) or rapid antigen test, anti-inflammatory or immunosuppressive treatments, comorbidities, dates of vaccination and number of doses received.
- Biological variable: quantitative anti-SARS-CoV-2 IgG titer.

2.4. Vaccination Scheme

The two vaccines administered to HOGIP staff were Sinopharm (BBIBP-CorV, two intramuscular doses 21 days apart) and AstraZeneca (ChAdOx1 nCoV-19, two intramuscular doses 90 days apart), in line with the recommendations issued by the Senegalese Directorate for Disease Prevention. According to the national authority, two doses were considered to confer complete vaccination status.

2.5. Anti-SARS-CoV-2 IgG Quantification

Quantitative determination of anti-SARS-CoV-2 IgG antibodies was performed by chemiluminescent microparticle immunoassay (CMIA) on the ARCHITECT ci4100 analyzer using the AdviseDx SARS-CoV-2 IgG II reagent kit (Abbott Diagnostics, USA). The assay detects IgG antibodies directed against the receptor-binding domain (RBD) of the S1 subunit of the spike protein. The assay is a two-step procedure in which the patient sample is first incubated with paramagnetic microparticles coated with recombinant SARS-CoV-2 RBD antigen; bound IgG is subsequently revealed by an acridinium-labelled anti-human IgG conjugate. Results are expressed in arbitrary units per millilitre (AU/mL). According to the manufacturer, a titer ≥50 AU/mL was interpreted as positive (anti-RBD IgG seropositivity), and <50 AU/mL as negative.

2.6. Statistical Analysis

Data were entered, cleaned and compiled using Microsoft Excel (Microsoft Corporation, USA). Statistical analyses were performed with JASP software. Because the quantitative variables did not follow a normal distribution and the sample size was modest (n = 61), nonparametric tests were used: the Mann-Whitney U test and the Kruskal-Wallis test for unpaired comparisons, the Wilcoxon test for paired comparisons, and the Spearman rank correlation coefficient for continuous variables. A p-value < 0.05 was considered statistically significant.

2.7. Ethical Considerations

The study was approved by the director and the medical establishment committee of HOGIP before initiation and was conducted in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent after being given the consent form. Data were anonymized; no personal identifier was recorded on the data collection forms or appeared in any subsequent use of the results. Biological samples were used exclusively for the purposes described in the consent form.

3. Results

3.1. Demographic Characteristics of the Study Population

Sixty-one hospital workers were enrolled. The cohort included 40 women (66%) and 21 men (34%). The median age was 44 years (range 19 - 64; interquartile range 34 - 53), with a standard deviation of approximately 12 years, indicating a heterogeneous age distribution. In addition, the median interval between the most recent vaccine dose and blood sampling was 29 months for the AstraZeneca group and 22 months for the Sinopharm group. This time interval did not differ significantly between the two vaccine groups (Mann-Whitney U = 408.0, p = 0.104) (**Table 1**).

Table 1. Demographic and vaccination characteristics of the study population (n = 61).

Variable	Value
Total participants, n	61
Sex ratio M/F	21/40
Median age, years (IQR)	44 (34 - 53)
Age range, years	19 - 64
Vaccinated, n (%)	52 (85.2%)
Unvaccinated controls, n (%)	9 (14.8%)
Sinopharm vaccinees, n	30
AstraZeneca vaccinees, n	22
Mean Sinopharm inter-dose interval, days	21
Mean AstraZeneca inter-dose interval, days	96
Time since last dose, months, Median (IQR) Aztra Zeneca[a]	61 29 (25 - 30)
Time since last dose, months, Median (IQR) Sinopharm[a]	22 (21 - 28)
Prevalence of comorbidities AztraZeneca group (%)[b]	(13.04%)
Prevalence of comorbidities Sinopharm group (%)[b]	(46.15%)
Absence of comorbidities AztraZeneca group (%)[b]	(86.96%)
Absence of comorbidities Sinopharm group (%)[b]	(53.85%)

a: p-value = 0.104, Mann-Whitney U test; b: p = 0.015, Fisher's exact test.

3.2. Vaccination Status

Out of 61 participants, 52 (85.2%) had received at least two doses of vaccine and 9 (14.8%) were unvaccinated controls. Among the vaccinated subjects, 30 had received the Sinopharm vaccine and 22 the AstraZeneca vaccine (Figure 1). The mean interval between the two doses was 21 days for Sinopharm and 96 days for AstraZeneca, in line with national vaccination recommendations (Table 1).

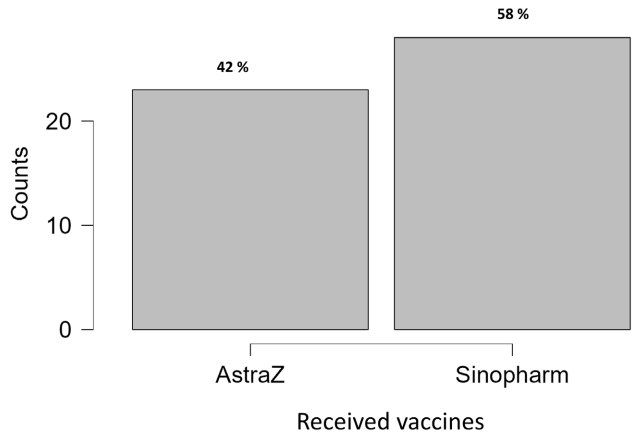

Figure 1. Distribution of the vaccinated participants according to the type of vaccine received (n = 52). Sinopharm (BBIBP-CorV) was administered to 30 participants and AstraZeneca (ChAdOx1 nCoV-19) to 22 participants.

3.3. Overall Seroconversion Rate

Using the manufacturer's threshold (≥50 AU/mL), anti-RBD IgG seropositivity was observed in 98% of vaccinated participants and in 100% of unvaccinated participants (Table 2). Only one participant, vaccinated with two doses of AstraZeneca, had an antibody titer below the anti-RBD IgG seropositivity threshold (6.7 AU/mL).

Table 2. Proportion of anti-RBD IgG seropositive individuals among vaccinated and unvaccinated participants.

Serological status	Vaccinated (n = 52)	Unvaccinated (n = 9)
Positive (≥50 AU/mL)	98%	98%
Negative (<50 AU/mL)	2%	0%

3.4. Antibody Titers by Vaccination Status and Vaccine Type

Median anti-SARS-CoV-2 IgG titers were higher in vaccinated participants than in unvaccinated controls. Within the vaccinated group, AstraZeneca recipients had a median titer of 4671.8 AU/mL while Sinopharm recipients had a median of 3177.5 AU/mL. This numerical difference between the two vaccines did not reach statistical significance (Mann-Whitney U test, p = 0.138). Unvaccinated controls had a median titer of 1408 AU/mL (Figure 2). The mean titer in the overall vaccinated group was 4393 AU/mL, compared with 1750 AU/mL in unvaccinated participants. The overall mean titer across the cohort was 4396 AU/mL.

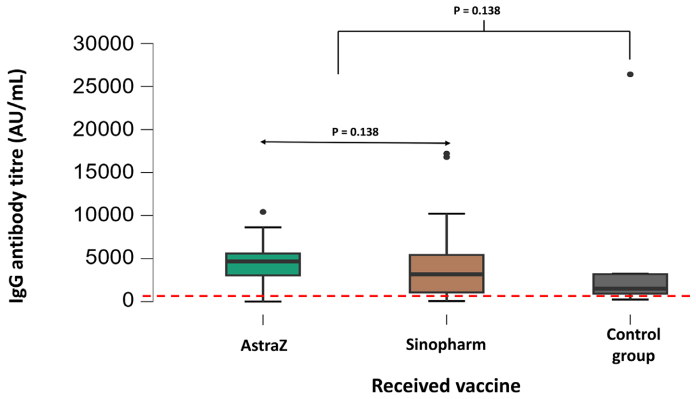

Figure 2. Mean anti-SARS-CoV-2 IgG antibody titers (AU/mL) according to vaccination status and vaccine type. Three groups are compared: AstraZeneca recipients (n = 22), Sinopharm recipients (n = 30) and unvaccinated controls (n = 9). Results are expressed in arbitrary units per millilitre (AU/mL); the dashed line represents the seropositivity threshold (50 AU/mL).

3.5. Factors Associated with Antibody Titers

When considering the overall cohort, among the variables tested (vaccination status, age, sex, comorbidities, type of vaccine and inter-dose interval), only vaccina-

tion status and age were significantly associated with antibody titers. Vaccinated participants displayed significantly higher median IgG titers than unvaccinated controls (Mann-Whitney U test, p = 0,027; Figure 3). Sex, the presence of comorbidities, the inter-dose interval and the type of vaccine had no statistically significant effect on antibody levels (Kruskal-Wallis and Mann-Whitney tests, p > 0.05; Figure 4). In the unvaccinated group, no one has any comorbidity. In contrast to the vaccinated group, 15 people in the vaccinated group had comorbidity. However, in the unvaccinated group, only one person has comorbidity. Regarding baseline health status, the proportion of participants with at least one comorbidity was significantly higher in the Sinopharm group compared to the AstraZeneca group (46.15% vs. 13.04%, p = 0.015, Fisher's exact test) (Table 1).

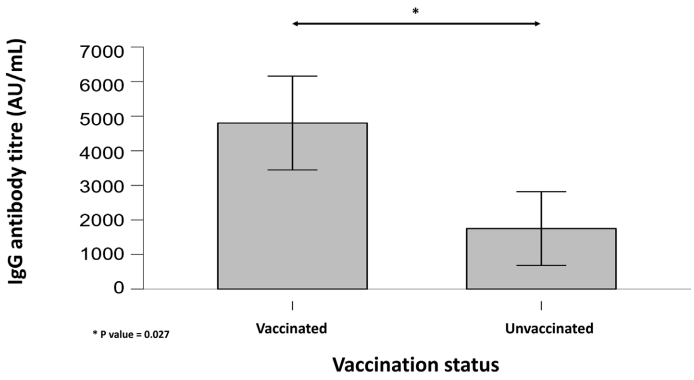

Figure 3. Comparison of anti-SARS-CoV-2 IgG titers between vaccinated and unvaccinated participants. Box plots show the median, interquartile range and individual values for each group. The Mann-Whitney U test indicated a statistically significant difference (p = 0.027).

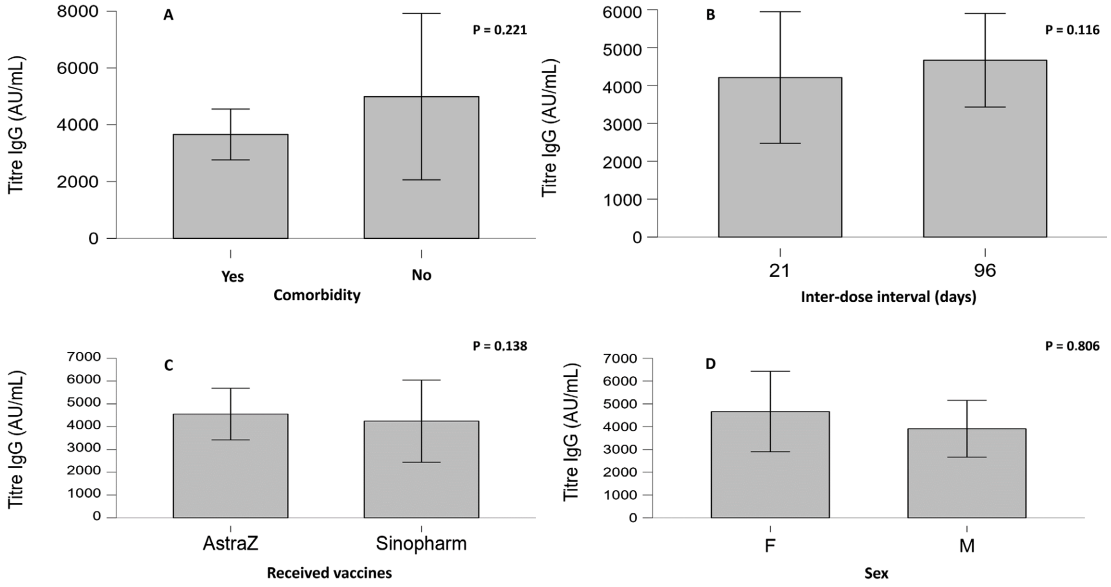

Figure 4. Comparison of overall anti-SARS-CoV-2 IgG titers according to non-significant covariates: (A) presence of comorbidities, (B) inter-dose interval, (C) vaccine type (Sinopharm vs AstraZeneca) and (D) sex. None of these variables showed a statistically significant association with antibody titers (Mann-Whitney U and Kruskal-Wallis tests, p > 0.05).

3.6. Correlation Analyses

Spearman rank correlation showed a significant positive correlation between age and anti-SARS-CoV-2 IgG titer ($\rho = 0.39$, p = 0.002), indicating that older participants tended to have higher antibody titers (Figure 5). A weaker but still significant positive correlation was also found between vaccination status and age ($\rho = 0.29$, p = 0.025).

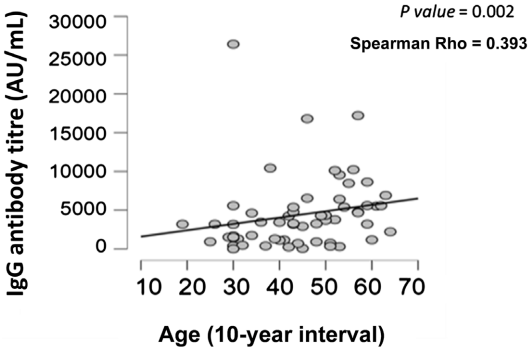

Figure 5. Spearman rank correlation between age (years) and anti-SARS-CoV-2 IgG antibody titer (AU/mL). Each point represents one participant. The correlation was statistically significant (Spearman $\rho = 0.39$, p = 0.002).

4. Discussion

The present study evaluated the serological profile of SARS-CoV-2 IgG antibodies among hospital workers at HOGIP in Dakar, Senegal, approximately one to two years after the introduction of vaccination in the country. Several findings deserve discussion.

First, study enrolment was based on voluntary participation over a continuous period, resulting in a sample size of 61 healthcare workers out of 500 eligible staff members. Because nonrespondents were not systematically tracked, a potential self-selection bias cannot be ruled out, which may affect the overall representativeness of our sample.

4.1. High Anti-RBD IgG Seropositivity in Both Vaccinated and Unvaccinated Participants

The 98% anti-RBD IgG seropositivity rate in vaccinated participants is consistent with prospective cohort studies of health-care workers conducted in other settings. The PASS (Prospective Assessment of SARS-CoV-2 Seroconversion) study, conducted at the Walter Reed National Military Medical Center, similarly showed high IgG seroconversion in vaccinated personnel together with detectable seroconversion in unvaccinated but exposed staff [9]. A study from the Hassan II University Hospital in Fez, Morocco, also reported a marked rise in anti-SARS-CoV-2 antibody titers in hospital workers after two vaccine doses, with variations according to vaccine platform [10].

More striking is the 100% anti-RBD IgG seropositivity rate observed in our small unvaccinated control group. This finding likely reflects repeated occupa-

tional exposure to SARS-CoV-2 in a hospital setting, where infection control measures cannot fully prevent contact with infected patients or contaminated environments. Earlier work has shown that natural infection consistently induces detectable IgG within 10 - 14 days, with seroconversion rates of around 95% in symptomatic patients [11]-[13]. The very high titers seen in our unvaccinated subjects further suggest cumulative or recent exposures rather than a single, distant infection.

4.2. Vaccine Platforms and Antibody Response

The two vaccines used at HOGIP were Sinopharm (an inactivated whole-virion vaccine) and AstraZeneca (a chimpanzee adenovirus-vectored vaccine). These platforms accounted respectively for 58% and 42% of vaccinations in our cohort, reflecting the supply received by Senegal in 2021, including a first batch of 200,000 doses of Sinopharm from China and more than 100,000 doses of AstraZeneca delivered through the COVAX facility.

AstraZeneca recipients in our cohort had higher median antibody titers than Sinopharm recipients (4671.8 vs 3177.5 AU/mL), although this difference did not reach statistical significance ($p = 0.138$). This pattern is consistent with the multicentre cross-sectional study published by Mansour Ghanaie *et al*., which compared mRNA, viral-vector and inactivated vaccines in health-care workers and found that viral-vector vaccines such as AstraZeneca induced higher antibody titers than inactivated vaccines such as Sinopharm [14]. However, in our analysis, the difference between the two vaccines did not reach statistical significance, most probably due to the limited sample size and to the high baseline antibody levels imposed on top of vaccination by ongoing occupational exposure.

The 21-day interval used for Sinopharm and the 96-day interval used for AstraZeneca matched the manufacturers' and national recommendations. For Sinopharm, Xia *et al*. demonstrated that two doses given 21 - 28 days apart elicit an optimal humoral response with high neutralizing antibody titers, in contrast with shorter 14-day schedules [15]. For AstraZeneca, a pooled analysis of phase 3 trials showed that an interval of around 12 weeks improved both immunogenicity and vaccine efficacy compared with shorter regimens [16].

4.3. High Overall Antibody Titers

The mean overall titer of 4396 AU/mL observed in our cohort is markedly higher than titers reported in nonhospital populations and in early phase trials. For instance, Xia *et al*. reported a mean Sinopharm-induced IgG titer of 211.2 IU/mL 42 days after the second dose [15], while for AstraZeneca, Folegatti *et al*. observed a titer of 639 EU/mL 28 days post second dose [17]. The difference is best explained by repeated, often unrecognized, exposure of hospital staff to SARS-CoV-2, which boosts vaccine-induced humoral responses through hybrid immunity. This hypothesis is reinforced by the high titers seen in our unvaccinated controls.

It is worth noting that two doses of vaccine alone may not be sufficient to main-

tain high antibody titers over time. A prospective study of 50 health-care workers vaccinated with an inactivated platform showed a measurable decline in IgG by day 28 post-second dose [18]. The WHO has accordingly recommended a third dose for individuals over 60 years of age and other at-risk groups [19]. Furthermore, emerging variants such as Beta (B.1.351), Delta and Omicron have been associated with reduced vaccine effectiveness and antibody escape [20]-[22], potentially explaining the single seronegative participant in our cohort despite two doses of AstraZeneca, although this individual's immune status could not be fully characterized.

4.4. Determinants of Seroconversion

Among the factors examined, only vaccination status and age were significantly associated with IgG titers ($p = 0.027$ and $p = 0.002$, respectively). The lack of significant effect of comorbidities in our cohort contrasts with previous reports suggesting that comorbidities may modulate the efficacy of the immune response and antibody-dependent enhancement risk [23]. Several hypotheses can account for this discrepancy, including the small number of participants with comorbidities and the heterogeneity of the conditions reported. Additionally, baseline health status differed between vaccine groups, with a higher prevalence of comorbidities observed among Sinopharm recipients (46.15% vs. 13.04%, $p = 0.015$). Because underlying chronic conditions can modulate humoral immune responsiveness, this baseline imbalance represents a potential confounding factor when directly comparing antibody titers between the two vaccine cohorts.

Information regarding confirmed prior SARS-CoV-2 infection (via RT-PCR or rapid antigen testing) could not be systematically established for all participants. Most reported previous episodes were based on clinical suspicion without documented laboratory confirmation or precise timing. Consequently, self-reported infection status was not included as a definitive variable to avoid recall and misclassification bias.

The positive correlation between age and IgG titer ($\rho = 0.39$, $p = 0.002$) is in agreement with reports showing that subjects over 60 years tend to develop higher post-vaccination antibody titers, possibly reflecting a more pronounced humoral response or more cumulative exposure to the virus [15]. Conversely, some studies have failed to identify a clear relationship between anti-RBD IgG seropositivity, age, sex and viral load, while highlighting a positive correlation with disease severity [13].

5. Conclusion

The serological evaluation of 61 hospital workers at HOGIP, Dakar, two years after the introduction of COVID-19 vaccination in Senegal, revealed a 98% anti-RBD IgG seropositivity rate among vaccinated participants and high IgG titers in both vaccinated and unvaccinated subjects. AstraZeneca recipients displayed higher median antibody titers than Sinopharm recipients, although the difference

did not reach statistical significance. Only vaccination status and age were significantly associated with antibody titers. These results suggest the potential presence of hybrid immunity among hospital staff, likely resulting from a combination of humoral responses induced by vaccination and by infections (some of which may not have been documented). They underscore the importance of ongoing serological monitoring of frontline staff to guide booster vaccination strategies in the African context. Larger and longitudinal studies, including mRNA vaccine recipients and a detailed assessment of cellular immunity and prior infections, are warranted to consolidate these observations.

Author Contributions

Conceptualization, C.D.F. and M.S.N.; methodology, C.D.F. and M.S.N.; software, C.D.F.; validation, C.D.F., M.S.N. and O.B.; formal analysis, C.D.F. and D.G.M.N.; investigation, C.D.F.; data curation, C.D.F.; writing—original draft preparation, C.D.F.; writing—review and editing, C.D.F.; M.S.N.; O.B; visualization, C.D.F.; M.S.N.; supervision, C.D.F.; M.S.N.; project administration, C.D.F. and M.S.N. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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