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SARS-CoV-2 Infection and Vaccine Effectiveness among Travelers Screened at the University Hospital of Fann, Dakar, Senegal

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Abstract

The COVID-19 pandemic led countries to implement strict public health measures, including systematic screening of international travelers and vaccination, to curb the spread of SARS-CoV-2. Several vaccines have been developed since the onset of the pandemic: inactivated whole-virus vaccines (Sinopharm), recombinant adenovirus vector vaccines encoding the spike protein (AstraZeneca, Johnson & Johnson, Sputnik-V), and mRNA vaccines (Pfizer and Moderna). This study aimed to determine the prevalence of SARS-CoV-2 infection among travelers tested at the University Hospital Center of FANN (CHNU de FANN) and to assess their vaccination status. It was a retrospective study conducted over an 11-month period, from October 2020 to August 2021. All travelers tested at CHNU de FANN were included. Nasopharyngeal samples were analyzed by RT-PCR using the Hummingbird device and Sansure Biotech reagents. Data were extracted from laboratory registers and patient forms, then analyzed with Epi Info software version 3.5.4. Out of 1,164 tests performed, 79 were positive (6.8%). Among the positive cases, 8 patients were under 14 years of age and 8 were over 60. A male predominance was observed (sex ratio = 1.6). Regarding vaccination, 236 travelers were fully vaccinated: Sinopharm (42), Pfizer (44), Johnson & Johnson (35), Moderna (22), AstraZeneca (46), and Sputnik-V (3). However, it should be noted that

only patients vaccinated with Sinopharm, Pfizer, Moderna, and Johnson & Johnson developed breakthrough infections. Among the positive cases, 8 had received the Sinopharm vaccine, 4 the Pfizer, 3 the Moderna, and 1 the Johnson & Johnson. These findings highlight the importance of pre-travel screening to limit viral transmission. Further analysis of SARS-CoV-2 variants would be beneficial for enhanced surveillance of viral circulation.

Keywords

Infection, SARS-CoV-2, Vaccine, Travelers

1. Introduction

SARS-CoV-2 infection, the causative agent of Coronavirus Disease 2019 (COVID-19), first emerged in late 2019 before rapidly spreading worldwide. This virus belongs to the *Coronaviridae* family, genus *Betacoronavirus*, and possesses a single-stranded positive-sense RNA genome. Transmission occurs primarily via respiratory droplets and aerosols, as well as through contact with contaminated surfaces. Transmission from infected but asymptomatic individuals was reported from the early stages of the outbreak [1]. The rapid spread and movement of people contributed to the global dissemination of COVID-19. This situation prompted most countries to adopt stringent public health measures to limit the spread of SARS-CoV-2, including systematic screening of international travelers and vaccination.

In Senegal, traveler screening is carried out in accredited laboratories such as the Department of Bacteriology-Virology of the University Hospital Center of FANN (CHNU de FANN), generally 24 to 48 hours before departure, in accordance with airline requirements.

A few months after the onset of the pandemic, several vaccines were developed: inactivated whole-virus vaccines (Sinopharm), recombinant adenoviral vector vaccines encoding the spike protein (AstraZeneca, Johnson & Johnson, Sputnik-V), and messenger RNA (mRNA) vaccines (Pfizer and Moderna).

Sinopharm: An inactivated whole-virus COVID-19 vaccine cultured on Vero cells. It is administered intramuscularly on day 0 and day 21 [2].

AstraZeneca**:** A non-replicating recombinant adenoviral vector vaccine expressing the gene encoding the SARS-CoV-2 spike (S) protein. It instructs host cells to produce the spike antigen, eliciting an immune response and memory cell formation. It is recommended for individuals aged 18 years and above, administered intramuscularly in two doses at an interval of 4 to 12 weeks [3].

Johnson & Johnson (Janssen): Developed by Janssen Pharmaceuticals (a subsidiary of Johnson & Johnson, USA), this is a non-replicating viral vector vaccine using a modified human adenovirus type 26 encoding the SARS-CoV-2 spike protein. It induces both humoral and cellular immune responses against COVID-19. The vaccine is administered as a single 0.5 mL intramuscular dose in adults aged 18 years and above and may also be used as a booster in heterologous vaccination

schedules [4].

Moderna: An mRNA-based vaccine developed against COVID-19. It delivers the genetic instructions (mRNA) for host cells to produce the SARS-CoV-2 spike protein, thereby eliciting immune protection and memory. It is administered intramuscularly in two doses, 28 days apart, for individuals aged 18 years and older [5].

Pfizer-BioNTech: An mRNA vaccine recommended for individuals aged 12 years and above. It is administered intramuscularly in two doses of 30 μg (0.3 mL each), spaced 28 days apart [6].

Therefore, we conducted this study with the objectives of determining the prevalence of SARS-CoV-2 infection among travelers tested at CHNU de FANN and assessing their vaccination status.

2. Methodology

2.1. Framework and Participants

The study was conducted in the Bacteriology-Virology Laboratory of the University Hospital Center of FANN (CHNU de FANN), specifically within the Molecular Biology Unit of the Pneumology Department. It was a retrospective study covering the period from October 2020 to August 2021.

All travelers tested for SARS-CoV-2 at CHNU de FANN during the study period were included. A standardized data collection form was completed for each patient to record relevant demographic, clinical, and epidemiological information. This systematic approach ensured complete traceability and allowed linkage between virological results and patient characteristics.

2.2. Sampling and Operating Protocol

Nasopharyngeal swabs were collected according to the World Health Organization (WHO) standardized protocol, ensuring the quality and representativeness of the specimens. Samples were immediately placed in viral transport medium (VTM) to preserve RNA stability during transport and prior to laboratory processing.

The viral inactivation step was performed in a water bath at 60˚C for 30 minutes—a key biosafety measure protecting laboratory personnel while maintaining RNA integrity for detection. After inactivation, sample preparation followed an optimized protocol: 10 μL of the specimen was mixed with 10 μL of lysis buffer and incubated for 10 minutes to release viral RNA. Subsequently, 30 μL of Sansure Biotech master mix was added, containing all components required for amplification.

The Sansure Biotech kit, validated for 2019-nCoV detection, is based on real-time PCR with fluorescence detection. It simultaneously targets multiple SARS-CoV-2 genes (ORF1ab, N, and E), increasing sensitivity and reducing false-negative results. An internal control using Rnase P RNA verifies sample quality and absence of PCR inhibitors. A positive control (PC) ensures amplification reliability, while a negative control (NC) confirms the absence of cross-contamination.

This rigorous protocol—combining standardized collection, safe inactivation, and highly specific amplification—enabled the production of reliable results within a short turnaround time. The use of the Sansure Biotech kit thus provided a robust diagnostic tool suited to pandemic conditions, where rapid and accurate testing is essential for surveillance and patient management.

Nucleic acid amplification was performed using the Hummingbird molecular diagnostic system, an automated real-time RT-PCR platform designed to enhance speed and reliability of virological analyses. This system, considered the gold standard for SARS-CoV-2 detection, allowed for a total processing time of approximately 1 hour and 20 minutes, representing a significant improvement over conventional platforms that often require several hours. Moreover, the Hummingbird system minimizes the risk of cross-contamination through a closed workflow and limited manual handling. Results with a cycle threshold (CT) value below 40 were considered positive.

Patients were considered fully vaccinated if they had received all required doses while adhering to the recommended intervals between doses.

2.3. Ethical Considerations

The study was conducted using routine diagnostic samples from patients who voluntarily presented for testing.

2.4. The Limitations of the Study

No data for January 2021 due to a reagent shortage. The vaccination status of most travelers was not reported.

2.5. Data Analysis

Data were extracted from laboratory registers and patient forms, then analyzed using Microsoft Excel software.

3. Results

A total of 1164 tests were performed during the study period, of which 79 were positive, corresponding to a positivity rate of 7% (**Figure 1**).

The positivity rate varied over time, with a peak observed in July and August 2021, corresponding to the third wave of COVID-19 in Senegal (**Figure 2**).

The mean Ct value was 27.13, with a range from 18 to 35.

Among the patients who tested positive, eight (8) were under 14 years of age and another eight (8) were over 60 years of age. A male predominance was observed, with a sex ratio of 1.6.

Regarding vaccination status (**Table 1**), 236 travelers were fully vaccinated: Sinopharm (42), Pfizer (44), Johnson & Johnson (35), Moderna (22), AstraZeneca (46), Sputnik-V (3). Vaccination status was not specified for the remaining patients. Among these vaccinated travelers, 16/236 tested positive; eight (8) had received the Sinopharm vaccine, four (4) the Pfizer vaccine, three (3) the Moderna

vaccine, and one (1) the Johnson & Johnson vaccine, resulting in respective positivity rates of 19% (8/42), 9% (4/44), and 13.6% (3/22) for each of these vaccines (Table 1 and Figure 3).

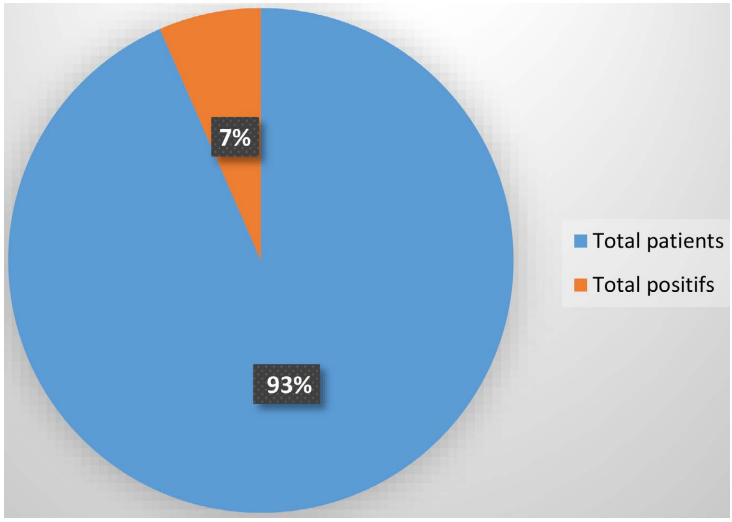

Figure 1. Prevalence of SARS-CoV-2 infection among travelers.

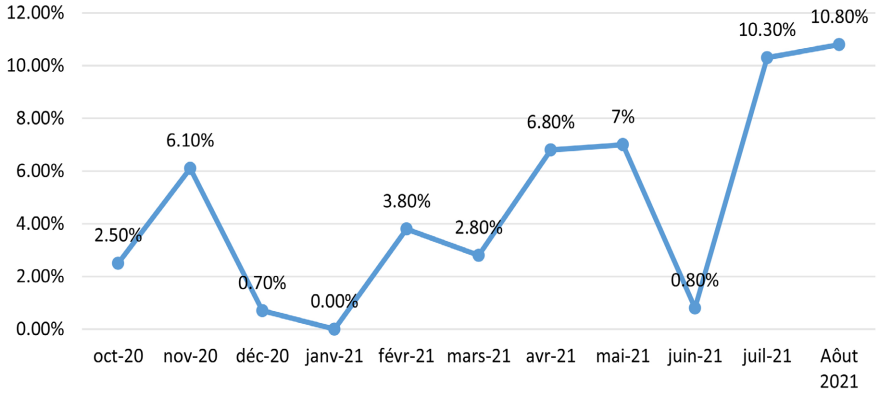

Figure 2. Positivity rate over time.

Table 1. Number of vaccinated travelers and positive tests.

Vaccines	Number of vaccinated	Number of vaccinated and positive
Sinopharm	42	08
Pfizer	44	04
Johnson-Johnson	35	01
Moderna	22	03
Astra-zeneca	46	00
Sputnik-V	03	00
Not specified	44	
Total	236	16

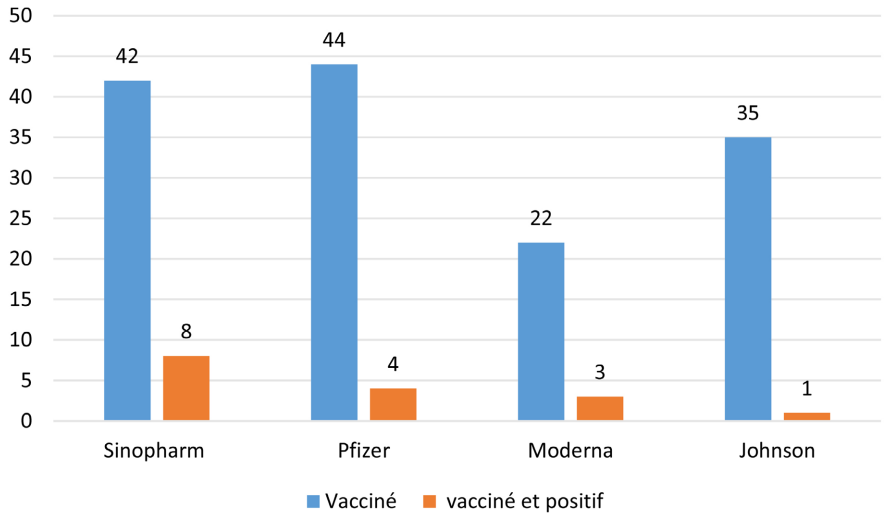

Figure 3. Incidence of breakthrough infections.

The mean Ct value was 27.13, with a range of 18 to 35.

Among the patients who tested positive, eight (8) were under 14 years of age and another eight (8) were over 60 years of age. A male predominance was observed, with a male-to-female ratio of 1.6.

4. Discussion

This study revealed a SARS-CoV-2 positivity rate of 7% among travelers tested for COVID-19. This rate is relatively low compared to some studies conducted in Africa. A study in Ghana by Asante *et al.* reported a slightly lower positivity rate (3.6%) among travelers screened at land borders [7]. Another study in the same country by Kwasi *et al.*, focusing on air travelers, found a similar positivity rate (6.7%) [8]. This prevalence remains relatively low compared to other African studies. For instance, a study conducted in the Democratic Republic of Congo reported a seroprevalence rate of 40.6% among tested travelers, which is substantially higher [9]. Differences in these positivity rates may be attributed to several factors, including screening methodologies, implemented health protocols, and the circulating viral variants during each study period [10].

A male predominance was observed (sex ratio of 1.6), consistent with numerous epidemiological studies suggesting that men are more susceptible to contracting COVID-19 and developing severe forms of the disease [11]. Biological sex-based differences, particularly in immune responses and the activity of the renin-angiotensin system, may explain this increased vulnerability in men [11].

In this study, 20.3% (236/1164) of travelers were fully vaccinated, with a majority having received the Sinopharm and Pfizer vaccines. Among the positive cases, eight travelers had been vaccinated with Sinopharm, raising questions regarding the relative efficacy of this vaccine compared to others, such as Pfizer or Moderna. Indeed, studies have shown that the Sinopharm vaccine (79.43%) has lower efficacy compared to vaccines like Pfizer (95%) and Moderna (94%) [12]. This differ-

ence could partially explain the relatively high number of positive cases among travelers vaccinated with Sinopharm. The observation of a higher rate of breakthrough infections with the Sinopharm vaccine is based on a very small sample size (n = 42) and should therefore be interpreted with caution, even though it is consistent with findings from larger studies.

Our results indicate that a small number of vaccinated travelers became infected (16/236), suggesting a degree of protection conferred by vaccination. In Canada in 2021, among 30,361 international travelers arriving at Calgary airport, only 0.02% (1 case among 5817 travelers) of those vaccinated or partially vaccinated tested positive for SARS-CoV-2. In comparison, 1.42% (341 cases among 24,034 travelers) of unvaccinated individuals tested positive [13]. However, some authors, such as Feng *et al.* in Israel, highlight potential inadequacies in vaccine coverage or reduced immunity against more transmissible variants [14]. Despite these breakthrough infections, it is clearly demonstrated that vaccination maintains effective protection against severe disease, including in elderly individuals [15].

The findings of our study align with international observations confirming that vaccination substantially reduces the risk of infection and, most importantly, of severe forms. Several cohort studies have shown a significant decrease in hospitalization and mortality rates among vaccinated individuals, even in the presence of variants of concern such as Delta and Omicron [16] [17]. Indeed, while vaccine efficacy against symptomatic infection may wane over time and vary depending on the circulating variant, protection against severe disease remains robust, often exceeding 80% after two doses [18]. This efficacy, which is enhanced by a booster dose, justifies the booster campaigns implemented in many countries.

It is also important to note that vaccine efficacy is influenced by several factors: the vaccine platform used, the interval between doses, patient age, and the presence of comorbidities [19]. mRNA vaccines, such as Pfizer-BioNTech and Moderna, have demonstrated superior performance in terms of protection against infection compared to viral vector vaccines, although all have shown a significant reduction in the risk of death [20].

In the context of international travel, vaccination plays a strategic role not only in individual protection but also in limiting the cross-border transmission of the virus.

It is also crucial to emphasize the contribution of combined strategies. Vaccination, when coupled with other preventive measures such as mask-wearing, physical distancing, and arrival testing, optimizes protection and further reduces the risk of spread [21]. Thus, vaccination should not be perceived as a standalone measure but integrated into a comprehensive pandemic control strategy. In Senegal, during the period from October 2020 to August 2021, the available vaccines were Sinopharm, AstraZeneca, Pfizer, Moderna, and Johnson & Johnson, but the availability of each vaccine varied over time. The majority of breakthrough infections involved Sinopharm, which could be explained by the fact that Sinopharm was one of the first vaccines available and was administered to a large number of travelers at the beginning of the vaccination campaign.

A major limitation of this study is that the vaccination status was unknown for the majority of travelers (928 out of 1164). This lack of information considerably limits the ability to interpret the results related to vaccine effectiveness and breakthrough infections. Indeed, without knowing the immune status of most participants, it becomes difficult to compare infection rates between vaccinated and unvaccinated individuals or to reliably estimate the frequency of breakthrough cases.

Furthermore, this information bias could lead to either an overestimation or an underestimation of the actual proportion of infections among vaccinated travelers. For instance, if vaccination data were more frequently missing among uninfected individuals, the apparent vaccine effectiveness might be underestimated. Conversely, if missing data were more common among positive cases, the effectiveness could appear higher than it truly is.

Finally, our results underscore the importance of broad and equitable vaccine coverage. Inequalities in vaccine access observed between high-income and low-income countries have fostered persistent viral circulation and the emergence of new variants. In this context, vaccinating travelers presents an opportunity to strengthen collective protection, but it must be part of a coordinated global strategy [22]. International cooperation is therefore essential to limit the risks of resurgence and prepare for future infectious threats.

5. Conclusion

This study determined the prevalence of SARS-CoV-2 infection among travelers managed at the CHNU of FANN and assessed vaccine effectiveness. The 7% positivity rate reflects persistent viral circulation in the population, independent of vaccination status. Although vaccination provided a certain level of protection, the occurrence of cases among vaccinated individuals underscores the necessity for optimal vaccine coverage and rigorous monitoring, particularly in the face of emerging variants. These findings highlight the importance of strengthening epidemiological surveillance and preventive measures in the context of international mobility. The reinforcement of surveillance mentioned in this study is particularly important in the context of international travel. Data on positivity rates and breakthrough infections among travelers can serve as an early warning tool to detect the circulation of new variants or a decline in vaccine effectiveness. Such information could help health authorities update border screening protocols, adapt vaccination strategies, and raise travelers' awareness about the importance of adhering to preventive measures before and after travel.

Conflicts of Interest

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

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