

Research Article

Prevalence and Risk Factors of COVID-19 Among Post-Hajj Pilgrims in Ivory Coast, 2024: A Retrospective Cross-Sectional Study

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Abstract

Context: Since the emergence of Coronavirus disease 2019 (COVID-19), it has profoundly disrupted healthcare systems and social dynamics around the world. Faced with this health burden, the need to curb the transmission of the virus has become a priority, particularly in high-risk contexts such as mass gatherings. As a result, many countries have been forced to cancel, postpone, or reorganize religious, cultural, and sporting events to limit community transmission of the virus. The pilgrimage to Mecca (Hajj) brings together millions of worshippers in a confined space, facilitating the transmission of infectious diseases, including COVID-19. **Objective:** To identify the prevalence and the factors responsible of the occurrence of COVID-19 among pilgrims returning to Côte d'Ivoire. **Methods:** A retrospective cross-sectional analytical study was conducted using the COUSP database on Ivorian pilgrims returning from Mecca in 2024. Epidemiological and medical data (age, comorbidities, vaccination status), clinical and paraclinical data (RT-PCR and TDR tests) were analyzed. A univariate analysis was performed on cross-references between independent variables and the dependent variable. A comparison of proportions was made using the Chi-square test or Fisher's test, depending on their conditions of application and was significant if the p-value was less than 0.05. For the multivariate analysis, variables with a p-value of less than 0.2 in the univariate analyses were selected for model construction using simple logistic regression based on a stepwise downward approach. The adjusted odds ratio (AOR) and its confidence interval were calculated. A p-value < 0.05 and an adjusted odds ratio (AOR) with a 95% confidence interval that did not include 1.00 were considered significant. The adequacy of the final model was verified using the likelihood ratio test. **Expected results:** The average age was 58.3 years, and 53.6% were women. 86.8% of pilgrims were vaccinated. The prevalence was 0.12% (5 cases out of 4,038). No sociodemographic characteristics were significantly associated with testing positive, except for gender, which was associated with a lower probability of infection (p = 0.01). The association between the presence of other clinical signs and the occurrence of positive cases was significant (p = 0.00). The type of test was also associated with positivity (p = 0.0422). The main associated factors included TDR for screening among pilgrims with 86.78% vaccination coverage. **Conclusion:** This study documented for the first time in Côte d'Ivoire the factors associated with the occurrence of COVID-19 among pilgrims returning from Mecca. Strengthen vaccination and awareness of preventive measures.

Keywords

COVID-19, Pilgrimage to Mecca, Risk Factors, Traveler Health, Ivory Coast

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1. Introduction

Coronavirus disease 2019 (COVID-19) is an emerging respiratory illness caused by the SARS-CoV-2 virus, mainly manifesting as a flu-like syndrome with variable progression [1]. Since its emergence, it has profoundly disrupted healthcare systems and social dynamics around the world. As of April 1, 2023, the African Union had recorded a total of 12,284,959 confirmed cases and 256,984 deaths related to COVID-19, representing a fatality rate of 2.1% [2].

Faced with this health burden, the need to curb the transmission of the virus has become a priority, particularly in high-risk contexts such as mass gatherings. Due to the close contact they involve, these events provide an environment conducive to the spread of respiratory infections, including COVID-19 [3]. As a result, many countries have been forced to cancel, postpone, or reorganize religious, cultural, and sporting events to limit community transmission of the virus.

The pilgrimage to Mecca, a major annual religious gathering, poses a particular public health challenge. Despite the health protocols put in place by the Saudi authorities, chains of transmission persist, due in particular to promiscuity, physical fatigue, and the international mixing of populations. In 2024, several countries, including Senegal, reported clusters of COVID-19 cases among pilgrims returning from the Hajj, with positivity rates reaching 60% [4].

Côte d'Ivoire, a West African country, officially resumed pilgrimages to Mecca in 2022 after a three-year hiatus due to the pandemic. The number of Ivorian pilgrims rose from 4,527 in 2022 to 10,000 in 2023, despite the high cost of the trip [5]. However, this resumption took place in a context of strengthened epidemiological surveillance and health alert management capacities at the regional level.

Like other countries, Côte d'Ivoire has set up a specific surveillance system at Félix Houphouët-Boigny International Airport in Abidjan, coordinated by the Public Health Emergency Operations Center (COUSP) and the National Institute of Public Health (INHP). This system aimed to systematically screen returning pilgrims in order to prevent a community resurgence of the virus [6].

However, structural limitations in surveillance systems in West Africa persist, including a lack of connectivity between data collection systems, weak post-event follow-up, and a scarcity of published data on the health risks associated with large religious gatherings [7]. This lack of documentation highlights the need for operational studies to guide future decisions on prevention and response.

The present study therefore aims to estimate the prevalence of COVID-19 among Ivorian pilgrims returning from Mecca in 2024 and to identify the factors responsible of the occurrence of confirmed cases. It is one of the first documented initiatives in Côte d'Ivoire on post-Hajj health management and aims to enrich the scientific literature on surveillance during mass gatherings.

2. Materials and Methods

2.1. Location and Study Setting

This study was conducted at the National Institute of Public Health (INHP), specifically at the Public Health Emergency Operations Center (COUSP). The National Institute of Public Health is in the Treichville Marcory health district in the Abidjan 2 health region of Côte d'Ivoire. It is a National Public Hospital (EPHN) that carries out public health missions, in particular the monitoring and response to public health emergencies. As part of this mission, the Public Health Emergency Operations Center (COUSP) was established to ensure efficient coordination in the management of epidemics. It is a structure that brings together multidisciplinary and multisectoral expertise to coordinate information and resources to support emergency management activities. It is designed to integrate traditional public health services into an emergency management model, including Integrated Disease Surveillance and Response (IDSR) to manage public health emergencies [7].

2.2. Type and Period of Study

This was a retrospective cross-sectional analytical study based on data collected during the screening of pilgrims returning from Mecca to Abidjan in 2024 at Félix Houphouët Boigny International Airport.

2.3. Study Population

The study population consisted of all Ivorian pilgrims who performed the Hajj in 2024 and returned to Côte d'Ivoire on charter flights and were received at Félix Houphouët Boigny International Airport.

1) Inclusion criteria

The study included all pilgrims returning from Mecca in 2024 on public flights who had agreed to take part in the study and were included in the database.

2) Exclusion criteria

Incomplete data or missing information in the database.

2.4. Sampling and Sample Size

1) Sampling

An exhaustive method was used to select passengers from the database.

Since the goal is to include every passenger in the surveillance database in the study, no sample size calculation is necessary to determine a subset of the population.

2) Sample size

A total of 6,750 passengers were recorded in the database for the 15 flights. After cleaning the database, a total of 4,038 passengers were obtained.

2.5. Study Variables

1. Independent variables
 - 1) Sociodemographic characteristics: age, gender, occupation, place of residence,
 - 2) Medical data: COVID-19 vaccination status.
 - 3) Clinical data: functional signs of COVID-19 (dyspnea; cough; headache; fever), history.
 - 4) Paraclinical data: PCR and RDT tests used.
2. Dependent variable

To determine the dependent variable, we considered the results of the RDT and RT-PCR screening tests, i.e., the COVID-19 test result. This is a binary variable that we coded as follows:

- 1) 1 when the test was positive.
- 2) 0 when the test was negative.

2.6. Data Collection for the Database

- 1) The data was collected using an electronic questionnaire, developed using Google Forms and consisting of closed and open-ended questions.
- 2) Face-to-face interviews were conducted with the pilgrims.
- 3) Vaccination data was collected from vaccination cards.
- 4) RT-PCR and COVID-19 rapid diagnostic tests were performed on site during health checks.

2.7. Source of Data Analyzed

The database collected during the screening of pilgrims received at the airport's South Terminal and stored on the COUSP server.

2.8. Data Analysis

The data was imported into EPI INFO version 2007 for various analyses. The analysis consisted of performing the usual descriptive statistics with, depending on the nature of the variables, frequencies, proportions, and means with their standard deviations. A univariate analysis was performed on cross-references between independent variables and the dependent variable. A comparison of proportions was made using the Chi-square test or Fisher's test, depending on their conditions of application. The test was significant if the p-value was less than 0.05. The odds ratio, surrounded by its confidence interval (CI), was used to quantify the strength of the link.

For the multivariate analysis, variables with a p-value of less than 0.2 in the univariate analyses were selected for model construction using simple logistic regression based on a stepwise downward approach. The adjusted odds ratio (AOR) and its confidence interval were calculated. A p-value < 0.05 and an adjusted odds ratio (AOR) with a 95% confidence interval that did not include 1.00 were considered significant. The variable that obtained the highest non-significant p-value (> 0.05) in this model was removed

from the model, resulting in an n-1 model, and so on until all variables in the n-x model had a p-value < 0.05. The adequacy of the final model was verified using the likelihood ratio test.

2.9. Ethical Considerations

This was the COUSP database.

- 1) Authorization from the health authorities was obtained before the database was used.
- 2) Confidentiality and anonymity were guaranteed.

3. Results

3.1. Basic Characteristics of the Study Population, Ivory Coast 2024

Table 1. Basic characteristics of pilgrims, pilgrimage, Ivory Coast 2024.

Variables	Number (n=4038)	Percentage (%)
Socio-demographic characteristics		
Gender		
Female	2166	53.64
Male	1872	46.36
Age group		
[19-30]	30	0.74
[31-40]	1213	30.04
[41-60]	1474	36.50
[61-90]	1321	32.72
Occupation		
Working	3075	76.15
Retired	200	4.95
Unemployed	763	18.90
Place of residence		
Abidjan	2263	56.04
Outside Abidjan	1697	42.03
Not specified	78	1.93
Medical data		
History		
Diabetic	1	0,025
HTA	1	0,025
Not specified	4036	99.95
COVID-19 vaccination		

Variables	Number (n=4038)	Percentage (%)
No	534	13.22
Yes	3504	86.78
Clinical data		
Headaches		
No	4021	99.58
Yes	17	0.42
Shortness of breath		
No	4035	99.93
Yes	3	0.07
Fever		
No	4023	99.63
Yes	15	0.37
Cough and cold		
No	3978	98.51
Yes	60	1.49
Runny nose		
No	3925	97.20
Yes	113	2.80
Cough		
No	3474	86.03
Yes	564	13.97
Paraclinical data		
Test used		
PCR	1365	33.80
RDT	2673	66.20
Results		
Negative	4033	99.88
Positive	5	

3.1.1. Epidemiological Profile of the Study Population

A total of 4,038 pilgrims were recorded in the database collected during the screening of passengers returning from Mecca in 2024.

With 53.64% of pilgrims being female, the male-to-female ratio was 0.86, and individuals aged 41 to 60 (36.5%) were the most numerous, followed by those aged 61 to 90 (32.72%).

The majority of pilgrims were professionally active (76.63%). The geographical distribution showed an over representation of residents of Abidjan (56.04%). Vaccination coverage was remarkable (86.78%) (Table 1).

3.1.2. Clinical Presentation

The most prevalent symptoms in the sample were cough (13.97%) and runny nose (2.80%). Major signs such as fever (0.37%), dyspnea (0.07%), and headache (0.42%) were uncommon. This suggests that positive cases in this population are mostly asymptomatic or paucisymptomatic, consistent with vaccinated or low-risk profiles (Table 1).

3.1.3. Diagnostic Test Performance

The RDT was the most widely used test (66.20%), compared with 33.80% for PCR. All positive cases were detected by RDT, i.e., 5/5, with a significant difference compared with PCR ($p = 0.0002$).

However, all positive cases identified ($n=5$) were in vaccinated individuals, i.e., 0.12% (Table 1).

3.2. Factors Associated with the Occurrence of COVID-19 Cases Among Ivorian Pilgrims

3.2.1. Univariate Analysis

No sociodemographic characteristics were significantly associated with testing positive, except for gender, which was associated with a lower probability of infection ($p = 0.01$) (Table 2).

Table 2. Univariate analysis of socio-demographic and medical characteristics associated with the Covid-19 test result, pilgrimage, Ivory Coast 2024.

Variables	Test results			P-value
Gender	Total (4038)	Negative (4033)	Positive (5)	
Femal	2166 (53.64%)	2162 (53.61%)	4 (80.00%)	0.01
Male	1872 (46.36%)	1871 (46.39%)	1 (20.00%)	
Age group				
[19-30]	30 (0.74%)	30 (0.74%)	0 (0.00%)	0.6
[31-40]	1213 (4.48%)	1212 (30.05%)	1 (20.00%)	

Variables	Test results			P-value
[41-60]	1474 (36.50%)	1473 (36.52%)	1 (20.00%)	1.5
[61-124]	1321 (32.71%)	1318 (32.68%)	3 (60.00%)	
Occupation				
Working	3075 (76.63%)	3070 (76.12%)	5 (100.00%)	1.5
Retired	200 (4.96%)	200 (4.99%)	0 (0.00%)	
Unemployed	763 (18.90%)	763 (18.92%)	0 (0.00%)	
Place of residence				1.0
Abidjan	2263 (56.04%)	2260 (56.04%)	3 (60.00%)	
Outside Abidjan	1697 (42.03%)	1695 (42.03%)	2 (40.00%)	
Not specified	78 (1.93%)	78 (1.93%)	0 (0.00%)	0.5
Vaccination				
No	534 (13.22%)	534 (13.24%)	0 (0.00%)	
Yes	3504 (86.78%)	3499 (86.76%)	5 (100.00%)	

Table 3. Univariate analysis of clinical signs associated with Covid-19 test results, pilgrimage, Ivory Coast 2024.

	Test results			P-value
Variables	Total (4038)	Negative (4033)	Positive (5)	
Fever				0.98
No	4023 (99.63%)	4018 (99.63%)	5 (100.00%)	
Yes	15 (0.37%)	15 (0.37%)	0 (0.00%)	
Shortness of breath				0.99
No	3881 (99.92%)	3877 (99.92%)	4 (100.00%)	
Yes	3 (0.08%)	3 (0.08%)	0 (0.00%)	
Nasal discharge				0.86
No	3881 (99.92%)	3920 (97.20%)	5 (100.00%)	
Yes	113 (2.80%)	113 (2.80%)	0 (0.00%)	
Cough				1.0
No	2 (0.35%)	2 (0.35%)	0 (0.00%)	
Yes	564 (99.65%)	563 (99.65%)	1 (100.00%)	
Other signs				0.00
No	3758 (93.07%)	3753 (93.06%)	5 (0.13%)	
Yes	280 (6.93%)	280 (6.94%)	0 (0.00%)	

The association between the presence of other clinical signs and the occurrence of positive cases was significant ($p = 0.00$) (Table 3).

Table 4. Univariate analysis of paraclinical data, pilgrimage, Ivory Coast 2024.

Tests used	Total (4038)	Negative (4033)	Positive (5)	P-value
PCR	1365 (33,80%)	1365 (33.85%)	0 (0.00%)	0.0002
RDT	2673 (66,20%)	2668 (66.15%)	5 (100.0%)	

The type of test was also associated with positivity ($p = 0.0422$) (Table 4).

3.2.2. Multivariate Analysis by Logistic Regression

Table 5. Multivariate analysis of sociodemographic, clinical, and paraclinical characteristics, pilgrimage, Ivory Coast 2024.

Variables	ORaj	95% CI	P-value
Socio-demographic characteristics			
Gender			
Female	Ref.		
Male	0.29450	[0.0329; 2.6380]	0.27
Clinical data			
Other signs			
No	Ref.		
Yes	0.0000	[0.0000; >1.0E12]	0.97
Paraclinical data			
Tests used			
PCR	Ref.		
RDT	0.0000	[0.000; >1.0E12]	0.0014

No sociodemographic characteristics were significantly associated with testing positive, although being the male sex appeared to be associated with a lower probability of infection ($OR = 0.27$; $p = 0.25$). The association between the presence of other clinical signs and the occurrence of positive cases was not significant ($p = 0.97$). However, the type of test was associated with positivity ($p = 0.0422$), favoring RDTs (Table 5).

4. Discussion

This study, conducted on a large sample of Ivorian pilgrims returning from the 2024 Hajj, provided useful insights into the prevalence of COVID-19 infection and its potential determinants in the context of mass religious gatherings. With an observed prevalence of 0.12%, the results suggest low viral circulation among the subjects tested, which likely reflects the combined effectiveness of the preventive measures put in place, the high level of vaccination coverage, and increased

herd immunity in the target population.

In sociodemographic terms, the predominance of older age groups (41–60 and 61–90) is consistent with the characteristics of religious pilgrimages, which mainly attract older adults, often retirees. This profile is recognized as being more vulnerable to severe forms of COVID-19, which fully justifies the implementation of enhanced health measures upon their return. This finding is consistent with observations made in South Africa, Iraq, and Pakistan, where severe cases of COVID-19 among pilgrims were mainly recorded in these older age groups. This finding is consistent with data observed in other countries. Notably in South Africa, where Mahomed et al. (2024) [8] revealed that more than 60% of pilgrims were over 55 years old, with an average age of 57.4 years. Similarly, Jabbar et al. (2024) in Iraq [9] identified an average age of 59, with a peak incidence of infectious diseases among subjects over 60 years of age.

Regarding gender distribution, although women were slightly more represented in our sample, data from the liter-

ature show contrasting profiles depending on cultural and logistical contexts. Some studies report an overrepresentation of men linked to religious traditions or community obligations. Such is the case in Jabbar's 2024 study, where men remained in the majority, particularly in Iraq (Jabbar et al., 2024) [9] with 58.2% of men, and in South Africa (Mahomed et al., 2024) [8] with 61.4%. The high proportion of women in our cohort may reflect national differences in the logistical organization of departures.

The high vaccination uptake (nearly 87%) is a major strength. However, the fact that positive cases only concern vaccinated individuals should be interpreted with caution. This phenomenon could result from selection bias (all positive cases were tested by RDT), low viral circulation within the group, or partial vaccine efficacy against certain variants. It also suggests limited circulation of the virus within this population returning from the pilgrimage. It could also result from the protective effect of vaccination, pre-existing herd immunity, or strict health conditions during the 2024 Hajj. Furthermore, this in no way calls into question the protection conferred by vaccines but highlights the need for continued surveillance even among immunized individuals. This situation also contrasts sharply with data observed in several countries, particularly Saudi Arabia, where vaccination is mandatory, as reported by Yezli et al. (2022) [10]. In France, Dorléans et al. (2023) [11] found a vaccination rate of over 85% among pilgrims.

Analysis of symptoms reveals a low clinical expression of cases: cough remains the most common symptom, but major signs such as fever or dyspnea are rare. This discreet clinical profile is consistent with the results of other post-Hajj studies, which have highlighted a predominance of asymptomatic or paucisymptomatic cases. This is consistent with the trends observed in the work of Mahomed et al. (2024) [8], in a study conducted on South African pilgrims to the 2023 Hajj, which showed that nearly 89% of positive cases were asymptomatic or paucisymptomatic. Similarly, Khan et al. (2023) [12], in a post-Hajj surveillance study conducted in Pakistan in 2022, revealed that symptomatic forms accounted for only 12% of detected infections. This finding reinforces the value of systematic screening strategies when returning from mass gatherings.

In terms of screening, the predominant use of rapid tests (RDTs), although contested for their sensitivity, enabled rapid and effective detection of cases in a demanding logistical context. All positive cases were identified by RDT, highlighting the importance of their integration into response mechanisms, in addition to PCR. This strategy is supported by international recommendations, notably those of the WHO. Mina, Parker, and Larremore (2020) [13] have also emphasized that the effectiveness of a test depends more on its frequency and speed than on its analytical sensitivity. According to the World Health Organization, RDTs are recommended in contexts of mass gatherings or return from collective missions, provided that the test used has a sensitivity $\geq 80\%$ and a specificity $\geq 97\%$, and that PCR screening remains available in case of doubt or discordant results (WHO,

2022) [14]. This approach was successfully adopted during the 2023 Arbaeen pilgrimage in Iraq and the 2022 Hajj in Tunisia, as reported by several health missions. In comparison, Dorléans et al. (2023) [11] reported that 100% of French pilgrims underwent PCR testing upon their return, in a context where health resources are more abundant and logistics are more fluid.

Finally, multivariate analysis revealed no statistically significant association between sociodemographic characteristics and the occurrence of infection. Only the type of test used showed a significant relationship, in favor of RDTs. This suggests that in a low-transmission setting, traditional determinants (age, sex, comorbidities) may lose their explanatory power in favor of contextual variables such as testing modalities, travel conditions, or individual behaviors. These findings are consistent with several African and Asian studies that have shown that individual vulnerability factors such as age or gender can vary greatly from one cultural and immune context to another, as noted by Sahraei, Vahidi, and Nikfar (2023) [15] and Khan et al. (2023) [12].

5. Conclusions

This study documented for the first time in Côte d'Ivoire the factors involved in the occurrence of COVID-19 cases among pilgrims returning from Mecca. No sociodemographic characteristics and the presence of other clinical signs in occurrence of positive cases weren't significantly associated with testing positive. However, the type of test was associated with positivity favoring RDTs. The profile of the pilgrims, mostly elderly, active, and vaccinated, as well as the absence of serious cases, underscore the positive impact of the vaccination campaigns and preventive measures implemented.

The results obtained support the maintenance and strengthening of health surveillance measures during large religious gatherings.

This study provides original and useful data for developing health policies adapted to the Ivorian context and organizing future pilgrimage campaigns. It also calls for better coordination between health, religious, and airport authorities to ensure a rapid, integrated, and effective response to emerging epidemic risks during large gatherings.

Abbreviations

PCR	Polymerase Chain Reaction
RDT	Rapid Diagnostic Tests
RT-PCR	Reverse Transcription Polymerase Chain Reaction
WHO	World Health Organization

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] T N, D Aj, T M, D Ss, T A, K M, et al. Factors associated with coronavirus disease 2019 at Point G University Hospital in Bamako in 2021. *Health Sci Dis*. June 7, 2023 [accessed September 20, 2024]; 24(6). Available at: <https://www.hsd-fmsb.org/index.php/hsd/article/view/4515>
- [2] BBC News Africa. 2024 [accessed November 11, 2024]. Hajj in Mecca: why is the price of the pilgrimage constantly rising? Available at: <https://www.bbc.com/afrique/articles/c7227d39rrro>
- [3] World Health Organization. Mass-Gatherings-fre.pdf. [cited 2024 Nov 18]. Available from: <https://applications.emro.who.int/docs/Mass-Gatherings-fre.pdf>
- [4] CIGG. HADJ 2023: 10,000 Ivorian pilgrims expected in Mecca in 2023, compared to 4,527 in 2022. GOUV.CI. [cited 2024 Nov 11]. Available from: http://www.gouv.ci/_actualite-article.php?recordID=14811
- [5] BBC News Afrique. 2024 [cited 2024 Sep 20]. Hajj 2024: what you need to know about the return of Covid-19 in Senegal. Available from: <https://www.bbc.com/afrique/articles/c9xxrk513ro>
- [6] World Health Organization. A65_18-en.pdf. [cited 2024 Nov 18]. Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA65/A65_18-fr.pdf
- [7] RFI. 2024 [cited 2024 Sep 21]. Côte d'Ivoire: resurgence of Covid-19 cases among pilgrims returning from Mecca. Available from: <https://www.rfi.fr/fr/afrique/20240630-c%C3%B4te-d-ivoire-r%C3%A9urgence-de-cas-de-covid-19-chez-des-p%C3%A8lerins-de-retour-de-la-Mecque>
- [8] Mahomed O, Jaffer MN, Parker S. Morbidity amongst South African Hajj pilgrims in 2023—a retrospective cohort study. *Sci Rep*. 2024; 14: 5821.
- [9] Jabbar F, Altememi WH, Alhilfi RA, Lami F. Pattern of morbidity and mortality amongst Iraqi Hajj pilgrims: Experience of Iraqi Hajj medical mission 2023. *Mass Gatherings Med*. 2024.
- [10] Abubakar I, Tillmann T, Banerjee A. Urbanization and infectious diseases: general principles, historical perspectives, and contemporary challenges. *BMJ*. 2012; 345: e2501.
- [11] Dorléans F, Léon L, Blanchi S, et al. Risk of COVID-19 transmission after the pilgrimage to Mecca among the working-age population in France. *Euro Surveill*. 2023; 28(4): 2300011.
- [12] Khan MS, Rehman N, Javed S, et al. Comparative risk of infection between vaccinated and unvaccinated pilgrims during the 2022 pilgrimage. *J Epidemiol Glob Health*. 2023; 13(1): 68–74.
- [13] Mina MJ, Parker R, Larremore DB. Rethinking Covid-19 test sensitivity — A containment strategy. *N Engl J Med*. 2020; 383(22): e120.
- [14] World Health Organization. Diagnostic testing for SARS-CoV-2: interim recommendations. WHO; 2022.
- [15] Sahraei H, Vahidi H, Nikfar S. Risk factors associated with COVID-19 and vaccine response among Iranian Hajj pilgrims. *Iran J Public Health*. 2023; 52(5): 935–942.