**ORIGINAL ARTICLE**

# Assessing COVID-19 Risks among Egyptian Healthcare Workers: Incidence, Reinfection, and Vaccination Insights: A Retrospective Study

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## ABSTRACT

***Background:*** *The onset of COVID-19 has posed significant hurdles for both public health and the global economy. The most effective strategy for managing the outbreak lies in the widespread embrace of vaccination. Numerous COVID-19 vaccines have been created and approved for deployment across different parts of the world.* ***Objective:*** *Identifying instances of COVID-19 infection and reinfection, analyzing the factors contributing to these occurrences, and assessing the vaccination status and potential side effects among healthcare workers.* ***Methodology:*** *This cross-sectional study involved healthcare workers from a university Hospitals. The questionnaire comprised four sections: participant demographics, initial COVID-19 infection, COVID-19 reinfection, and vaccination status.* ***Results:*** *Healthcare workers faced elevated risks of both initial infection (46.4%) and reinfection (29.2%) due to potential transmission within the healthcare setting, as well as from patients and the wider community. Reinfection cases typically exhibited more severe symptoms compared to initial infections, leading to increased rates of hospitalization and intensive care unit admissions (p value <0.001). AstraZeneca (24.6%), Pfizer (23.8%), Sinopharm (20.9%), and Sinovac (20.2%) emerged as the most administered vaccines. Non-vaccinated participants faced heightened susceptibility to COVID-19 infection, experienced more severe symptoms, and were more likely to require hospitalization. Following vaccination, side effects were more commonly reported with Johnson & Johnson (47.6%%) and Sputnik vaccines (46.7%%), typically manifesting within the first day and lasting one to three days.* ***Conclusions:*** *Understanding the risk factors for COVID-19 infection and reinfection is crucial for developing effective prevention strategies, especially among healthcare workers who face heightened exposure.*

## INTRODUCTION

The COVID-19 pandemic has caused significant illness and death worldwide since late 2019, with millions of confirmed cases and deaths annually.[1,2] Efforts to curb its spread have included various measures, with vaccination playing a pivotal role in preventing transmission and severe illness.[3-5] However, vaccine effectiveness may wane over time, leading to calls for booster shots.[6-9] Understanding the risk factors for reinfection is crucial for developing effective prevention strategies, especially among healthcare

workers who face heightened exposure.[10] Yet, detailed data on reinfection rates and risk factors remain limited.[8,11] As the number of suspected and confirmed reinfections rises, determining appropriate measures to combat COVID-19 is important. Given their elevated risk of exposure, healthcare workers are a focus of this study, which aims to analyze infection and reinfection rates, identify associated risk factors, and evaluate vaccination status and related side effects.

## METHODOLOGY

**The study design:**

A retrospective cohort study was conducted from June 2022 to December 2023 in Egypt using a self-administered hard copy and an online questionnaire survey. This study acquired an approval letter from the Research Ethics Committee (REC) of the Faculty of Medicine, Cairo University under the reference number N-487-2023, all methods were performed in accordance with the relevant guidelines and regulations.

**Sampling Technique**

An online survey was designed to detect COVID-19 infection and reinfection details which were checked and confirmed from testing platforms of the main laboratory (polymerase chain reaction (PCR) test for COVID-19, antibody test, rapid antigen test), and the vaccination status of the healthcare workers which was checked and confirmed from the vaccination platforms of the Infection Prevention and Control office. A total of 1793 participants participated in the study.

Social media platforms (such as Facebook, WhatsApp, and Telegram) were used to help distribute the online survey to participants. The online survey created by using Google Forms.

**Data Collection**

Data was collected from from healthcare workers of Cairo University Hospitals. The time needed to complete the survey was estimated to be 10 minutes. The questionnaire was divided into four parts; Participant's demographic data; First Time COVID-19 Infection; COVID-19 Reinfection and Vaccination Status. It included information about the Participant's demographic data (Age, and Sex), Type of working personnel, medical conditions (medical comorbidities, COVID-19 infection, and reinfection, different symptoms if present, Hospital admission, and intensive care unit (ICU) admission), treatment needed (Oxygen inhalation, and Mechanical ventilation need), Vaccine (types, dosage, and side effects), and Compliance with infection control preventive measures (hand washing, using surgical masks, and social distancing).

**Inclusion and Exclusion criteria**

The study included healthcare workers at the University who do not work outside this University Hospitals. Workers who refused to participate had been excluded.

**Definition of reinfection**

Reinfection was defined in this study as a positive COVID-19 PCR test or rapid antigen test at least 90 days following the initial positive test, regardless of symptoms.[12]

## RESULTS

**Participants' demographic data:**

A total of 1793 (1251 females) participants completed the study. The majority of them (89%) were in the age group of 18 to 39 years. 60.4% of them were students. 89.4% followed the preventive measures during the COVID-19 pandemic. Wearing a mask was the most frequently used preventive measure during the COVID-19 pandemic (95%) followed by hand hygiene (88.2%). 67.4% of them had received the Influenza vaccine during the COVID-19 pandemic (Table. 1).

**Table 1: Demographic characteristics**

| Variable | Number | Percentage |
|---|---|---|
| **Age** | | |
| 0-17y | 11 | 0.6 |
| 18-39y | 1595 | 89.0 |
| 40-59y | 172 | 9.6 |
| 60y or more | 15 | 0.8 |
| **Sex** | | |
| Males | 542 | 30.2 |
| Females | 1251 | 69.8 |
| **Type of Healthcare Worker** | | |
| Student | 1083 | 60.4 |
| Nurse/Nurse aid | 150 | 8.4 |
| Resident | 154 | 8.6 |
| Staff | 319 | 17.8 |
| Lab tech/Chemist | 32 | 1.8 |
| Radiology Technician | 8 | 0.4 |
| Worker | 30 | 1.7 |
| Administrative | 17 | 0.9 |
| **Presence of Risk Factors for COVID-19 infection** | | |
| Yes | 440 | 24.5 |
| No | 1353 | 75.5 |
| **Type of Risk Factors** | | |
| Chronic chest disease | 164 | 37.5 |
| Cardiac disease | 87 | 19.9 |
| Obesity | 122 | 27.9 |
| Immunodeficiency | 141 | 32.3 |
| Diabetes Mellitus | 92 | 21.1 |
| Kidney disease | 37 | 8.5 |
| Liver disease | 35 | 8.0 |
| Hypothyroidism | 46 | 10.5 |
| Malignancy | 44 | 10.1 |
| Chemotherapy | 41 | 9.4 |
| Others | 122 | 28.0 |
| **Compliance with preventive measures during the COVID pandemic** | | |
| Yes | 1603 | 89.4 |
| No | 190 | 10.6 |
| **Type of Preventive measures during COVID pandemic** | | |
| 1= Physical distance | 1275 | 79.5 |
| 2= Wearing mask | 1523 | 95.0 |
| 3= Hand hygiene | 1414 | 88.2 |
| **History of Influenza vaccination during COVID pandemic** | | |
| Yes | 584 | 32.6 |
| **No** | 1209 | 67.4 |

**First Time COVID-19 Infection**

A total of 589 (393 females) participants had COVID-19 infections. Many of them were in the age group of 18 to 39 years (84.6%). 41.4% of them were students. 92.5% of them followed the preventive measures during the COVID-19 pandemic. Wearing a mask was the most frequently used preventive measure during the COVID-19 pandemic (96.1%) followed by hand hygiene (87.9%). 35% of them have received the Influenza vaccine during the COVID-19 pandemic (Table 2).

**Table 2: Demographic characteristics of first-time infected participants**

| Variable | Number | Percentage |
|---|---|---|
| **Age** | | |
| 0-17y | 6 | 1.0 |
| 18-39y | 498 | 84.6 |
| 40-59y | 80 | 13.6 |
| 60y or more | 5 | 0.8 |
| **Sex** | | |
| Males | 196 | 33.3 |
| Females | 393 | 66.7 |
| **Type of Healthcare Worker** | | |
| Student | 244 | 41.4 |
| Nurse/Nurse aid | 42 | 7.1 |
| Resident | 85 | 14.4 |
| Staff | 183 | 31.1 |
| Lab tech/Chemist | 8 | 1.4 |
| Radiology Technician | 6 | 1.0 |
| Worker | 13 | 2.2 |
| Administrative | 8 | 1.4 |
| **Presence of Risk Factors for COVID-19 infection** | | |
| Yes | 149 | 25.3 |
| No | 440 | 74.7 |
| **Type of Risk Factors** | | |
| Chronic chest disease | 41 | 27.7 |
| Cardiac disease | 22 | 14.9 |
| Obesity | 43 | 29.1 |
| Immunodeficiency | 35 | 23.6 |
| Diabetes Mellitus | 32 | 21.6 |
| Kidney disease | 9 | 6.1 |
| Liver disease | 8 | 5.4 |
| Hypothyroidism | 15 | 10.1 |
| Malignancy | 8 | 5.4 |
| Chemotherapy | 5 | 3.4 |
| Others | 47 | 31.8 |
| **Compliance with preventive measures during COVID-19 pandemic** | | |
| Yes | 545 | 92.5 |
| No | 44 | 7.5 |
| **Type of Preventive measures during COVID-19 pandemic** | | |
| 1= Physical distance | 414 | 76.0 |
| 2= Wearing mask | 524 | 96.1 |
| 3= Hand hygiene | 479 | 87.9 |
| **History of Influenza vaccination during COVID-19 pandemic** | | |
| Yes | 206 | 35.0 |
| No | 383 | 65.0 |

**COVID-19 Reinfection**

**Comparison between first-time infected and reinfected participants (Table 3)**

Regarding the first infection with COVID-19:

Almost half of the participants (46.4%) reported that they had a COVID-19 infection once time and 86.5% reported that they did not travel in 14 days before the infection. 41.3% of the participants had COVID-19 infection during the period from March 2020 to February 2021. 47.1% of participants with COVID-19 infection were diagnosed by PCR. Regarding the COVID-19 symptoms, 79% suffered from fever, 64.8% suffered from cough, 60.1% lost the smell, and 54.7% lost the taste. 13.2% of the participants needed to be admitted to the hospital and 6.5% needed ICU admission. Moreover, 16% needed oxygen inhalation, and 7.2% needed mechanical ventilation.

Regarding the number of vaccinations, 31.8% were vaccinated once and 51% were vaccinated twice. Regarding the type of COVID-19 vaccine, 25.2% of the

participants received Pfizer, 25.2% received Sinopharm, 17.7% Sinovac and 27.9% received AstraZeneca vaccines.

Of all the participants, 35% suffered from COVID-19 vaccination side effects. The common post-COVID-19 vaccination side effects were fatigue (71.2%), fever (58.3%), pain and redness at the vaccination site (50.9%), and headache (49.1%).

Nearly half of the participants (49.7%) reported that the side effects appeared after the first dose during the first day after vaccination and the second day after vaccination in 46.6% of the participants. The side effects persisted for 1-3 days in 77.9% of the participants, for 3-5 days in 16%, and more than 5 days in 6.1% of them.

**Regarding the reinfection with COVID-19:**

29.2% of the participants who were infected for the first time reported that they got reinfected with COVID-19 and 75.7% reported that they did not travel in 14 days before the infection. 45.3% of the participants had COVID-19 infection during the period between December 2021 and February 2022. 51% of participants with COVID-19 infection were diagnosed by PCR. Regarding the COVID-19 symptoms, 72.3% suffered from fever, 59.8% complained of cough, 54% from Myalgia/Body aches, and 51.8% had Headache. 21.3% of the participants needed to be admitted to the hospital and 16.9% needed ICU admission. Moreover, 24.9% needed oxygen inhalation and 16.4% needed mechanical ventilation. Regarding the number of vaccinations, 34.2% were vaccinated once and 49.7% were vaccinated twice. Regarding the type of COVID-19 vaccine, 31.1% of the participants received Pfizer, 23.3% received Sinopharm, 19.7% Sinovac and 21.8% received AstraZeneca vaccines.

Of all the participants, 57.5% suffered from COVID-19 vaccination side effects. The most common post-COVID-19 vaccination side effects were fatigue (69.4%), fever (55.9%), pain and redness at the vaccination site (55%), and headache (49.5%). More than half of the participants (58.6%) reported that the side effects appeared after the first dose during the first day after vaccination and the second day after vaccination in 37.8% of the participants. The side effects persisted for 1-3 days in 69.4% of the participants, for 3-5 days in 23.4%, and more than 5 days in 7.2%of them.

**Table 3: Comparison between first-time infected and reinfected participants**

| | Infected for the first time | | Reinfected | | P value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| **Infection source and route** | | | | | |
| – Community | 221 | 37.5% | 107 | 44.0% | **< 0.001** |
| – Hospital | 161 | 27.3% | 92 | 37.9% | |
| – Unknown | 207 | 35.1% | 44 | 18.1% | |
| **History of traveling 14 days previously to the infection** | | | | | |
| – Yes | 54 | 9.2% | 58 | 23.9% | **< 0.001** |
| – No | 535 | 90.8% | 185 | 76.1% | |
| **Infection period** | | | | | |
| – Mar 2020- Feb 2021 | 227 | 38.5% | 117 | 48.1% | **0.009** |
| – Mar 2021- Nov 2021 | 227 | 38.5% | 90 | 37.0% | |
| – Dec 2021- Feb 2022 | 135 | 22.9% | 36 | 14.8% | |
| **Testing type for diagnosis of COVID-19 infection** | | | | | |
| – PCR | 247 | 41.9% | 145 | 59.7% | **< 0.001** |
| – Antibody | 26 | 4.4% | 17 | 7.0% | |
| – Rapid antigen | 38 | 6.5% | 13 | 5.3% | |
| – Self-home test | 46 | 7.8% | 19 | 7.8% | |
| – Don't know | 232 | 39.4% | 49 | 20.2% | |
| **Symptoms of COVID-19 infection** | | | | | |
| – 1= Fever | 423 | 78.2% | 187 | 81.0% | 0.388 |
| – 2= Runny nose | 270 | 49.9% | 112 | 48.5% | 0.717 |
| – 3= Cough | 342 | 63.2% | 158 | 68.4% | 0.168 |
| – 4= Wheezing | 98 | 18.1% | 54 | 23.4% | **0.092** |
| – 5= Shortness of breath | 197 | 36.4% | 101 | 43.7% | **0.056** |
| – 6= Chest pain | 133 | 24.6% | 81 | 35.1% | **0.003** |
| – 7= Loss of taste | 297 | 54.9% | 125 | 54.1% | 0.841 |
| – 8= Loss of smell | 335 | 61.9% | 129 | 55.8% | 0.114 |
| – 9= Nausea/vomiting | 68 | 12.6% | 44 | 19.0% | 0.019 |
| – 10= Abdominal pain/Diarrhea | 119 | 22.0% | 62 | 26.8% | 0.146 |
| – 11= Headache | 287 | 53.0% | 143 | 61.9% | **0.023** |

| | Infected for the first time | | Reinfected | | P value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| – 12= Myalgia/Body aches | 331 | 61.2% | 140 | 60.6% | 0.880 |
| – 13= Sore throat | 283 | 52.3% | 113 | 48.9% | 0.388 |
| – 14= Pink eyes | 56 | 10.4% | 27 | 11.7% | 0.583 |
| – 15= Rash | 16 | 3.0% | 11 | 4.8% | 0.213 |
| **Need for Hospital admission** | | | | | |
| – Yes | 46 | 8.5% | 56 | 24.2% | **< 0.001** |
| – No | 496 | 91.5% | 175 | 75.8% | |
| **Need for ICU admission** | | | | | |
| – Yes | 13 | 2.4% | 37 | 16.0% | **< 0.001** |
| – No | 529 | 97.6% | 194 | 84.0% | |
| **Number of COVID-19 vaccination times** | | | | | |
| – Once | 149 | 31.8% | 66 | 34.2% | 0.816 |
| – Twice | 239 | 51.0% | 96 | 49.7% | |
| – More | 81 | 17.3% | 31 | 16.1% | |
| **Number of doses in each time of vaccination** | | | | | |
| – Full dose | 422 | 90.0% | 180 | 93.3% | 0.181 |
| – No full dose | 47 | 10.0% | 13 | 6.7% | |
| **Type of COVID-19 vaccination** | | | | | |
| – 1= Pfizer | 118 | 25.2% | 60 | 31.1% | 0.118 |
| – 2= Sinopharm | 116 | 24.7% | 45 | 23.3% | 0.699 |
| – 3= Sinovac | 83 | 17.7% | 38 | 19.7% | 0.547 |
| – 4= Sputnik | 12 | 2.6% | 7 | 3.6% | 0.454 |
| – 5= Moderna | 12 | 2.6% | 5 | 2.6% | 0.981 |
| – 6= Johnson and Johnson | 30 | 6.4% | 13 | 6.7% | 0.872 |
| – 7= AstraZeneca | 131 | 27.9% | 42 | 21.8% | 0.101 |
| – 8= Others | 6 | 1.3% | 3 | 1.6% | 0.725 |
| – 9= Do not know | 24 | 5.1% | 7 | 3.6% | 0.409 |
| **Presence of Side effects of COVID-19 vaccination** | | | | | |
| – Yes | 163 | 34.8% | 111 | 57.5% | **< 0.001** |
| – No | 306 | 65.2% | 82 | 42.5% | |
| **Side effects of COVID-19 vaccination** | | | | | |
| – 1= Pain and redness at the vaccination site | 83 | 50.9% | 61 | 55.0% | 0.511 |
| – 2= Fatigue | 116 | 71.2% | 77 | 69.4% | 0.749 |
| – 3= Fever | 95 | 58.3% | 62 | 55.9% | 0.690 |
| – 4= Chills | 37 | 22.7% | 26 | 23.4% | 0.889 |
| – 5= Headache | 80 | 49.1% | 55 | 49.5% | 0.939 |
| – 6= Nausea/Vomiting | 11 | 6.7% | 17 | 15.3% | **0.022** |
| – 7= Joint/Bone pain | 80 | 49.1% | 33 | 29.7% | **0.001** |
| – 8= Others | 11 | 6.7% | 6 | 5.4% | 0.651 |
| **Symptoms of vaccination side effects started on** | | | | | |
| – Vaccination day | 81 | 49.7% | 65 | 58.6% | 0.340 |
| – 2nd day | 76 | 46.6% | 42 | 37.8% | |
| – 3rd day | 6 | 3.7% | 4 | 3.6% | |
| **Duration of side effects lasted for** | | | | | |
| – 1-3 days | 127 | 77.9% | 77 | 69.4% | 0.258 |
| – 3-5 days | 26 | 16.0% | 26 | 23.4% | |
| – > 5 days | 10 | 6.1% | 8 | 7.2% | |

Bold values are significant at p<0.05.

**Vaccination Status**

Regarding the number of COVID-19 vaccinations, 36% of all the participants were vaccinated twice times but on the other hand, 28% of them did not receive any vaccination. 85.3% of the participants reported that fear was the main cause of non-vaccination followed by pregnancy (10.7%) and lactation (6.7%). AstraZeneca and Pfizer vaccines were the most received vaccines by the participants in this study.

Table 4 shows the participant's vaccination status.

**Table 4.** Vaccination status

| | Number | Percentage |
|---|---|---|
| **Number of COVID-19 vaccination times** | | |
| – Once | 442 | 24.7 |
| – Twice | 645 | 36.0 |
| – More | 204 | 11.4 |
| – Never | 502 | 28.0 |
| **The cause of non-vaccination** | | |
| – 1= Fear | 423 | 85.3 |
| – 2= Pregnancy | 53 | 10.7 |
| – 3= Lactation | 33 | 6.7 |
| – 4= Neurological e.g. epilepsy | 7 | 1.4 |
| – 5= Uncontrolled Diabetes Mellitus | 9 | 1.8 |
| – 6= Uncontrolled hypertension | 13 | 2.6 |
| – 7= HIV infection | 1 | 0.2 |
| – 8= Cardiac disease | 11 | 2.2 |
| – 9= Immunosuppressive therapy | 6 | 1.2 |
| – 10= Coagulopathy | 19 | 3.8 |
| – 11= Allergy | 28 | 5.6 |
| **Number of doses in each time of vaccination** | | |
| – Full dose | 1,165 | 90.2 |
| – No full dose | 126 | 9.8 |
| **Type of COVID-19 vaccination** | | |
| – 1= Pfizer | 308 | 23.8 |
| – 2= Sinopharm | 270 | 20.9 |
| – 3= Sinovac | 262 | 20.2 |
| – 4= Sputnik | 27 | 2.1 |
| – 5= Moderna | 45 | 3.5 |
| – 6= Johnson and Johnson | 77 | 6.0 |
| – 7= AstraZeneca | 318 | 24.6 |
| – 8= Others | 19 | 1.5 |
| – 9= Unknown | 87 | 6.7 |
| **Presence of Side effects of COVID-19 vaccination** | | |
| – Yes | 475 | 36.8 |
| – No | 816 | 63.2 |
| **Side effects of COVID-19 vaccination** | | |
| – 1= Pain and redness at the vaccination site | 249 | 52.4 |
| – 2= Fatigue | 338 | 71.2 |
| – 3= Fever | 280 | 58.9 |
| – 4= Chills | 108 | 22.7 |
| – 5= Headache | 250 | 52.6 |
| – 6= Nausea/Vomiting | 51 | 10.7 |
| – 7= Joint/Bone pain | 189 | 39.8 |
| – 8= Others | 34 | 7.2 |
| **Symptoms of vaccination side effects started on:** | | |
| – Vaccination day | 245 | 51.6 |
| – 2$^{nd}$-day post-vaccination | 217 | 45.7 |
| – 3$^{rd}$-day post-vaccination | 13 | 2.7 |
| **Duration of side effects lasted for:** | | |
| – 1-3 days | 369 | 77.7 |
| – 3-5 days | 75 | 15.8 |
| – > 5 days | 31 | 6.5 |

Regarding the different types of vaccines, the after-vaccination side effects were more prevalent after the Johnson and Johnson vaccine (47.6%) followed by the Sputnik vaccine (46.7%). The most reported side effects were pain and redness at the vaccination site, fatigue, and fever. The side effects appeared during the first day after vaccination with Pfizer, Sinopharm, Sinovac, Sputnik, Johnson and Johnson, and AstraZeneca. However, they appeared on the second day after the Moderna vaccine. The side effects commonly lasted for 1 to 3 days after vaccination with Pfizer, Sinopharm, Sinovac, Moderna, Johnson and Johnson, and AstraZeneca. However, the side effects have mostly lasted for 3 to 5 days after vaccination with Sputnik.

Table 5 shows a Comparison between different types of vaccines.

**Table 5: Comparison between different types of vaccines**

| | Pfizer | | Sinopharm | | Sinovac | | Sputnik | | Moderna | | Johnson and Johnson | | AstraZeneca | | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | |
| **Presence of Side effects of COVID-19 vaccination** | | | | | | | | | | | | | | | |
| – Yes | 109 | 44.7% | 48 | 21.1% | 70 | 30.2% | 7 | 46.7% | 10 | 32.3% | 30 | 47.6% | 108 | 40.8% | **< 0.001** |
| – No | 135 | 55.3% | 180 | 78.9% | 162 | 69.8% | 8 | 53.3% | 21 | 67.7% | 33 | 52.4% | 157 | 59.2% | |
| **Side effects of COVID-19 vaccination** | | | | | | | | | | | | | | | |
| – 1= Pain and redness at the vaccination site | 52 | 47.7% | 28 | 58.3% | 36 | 51.4% | 4 | 57.1% | 3 | 30.0% | 18 | 60.0% | 63 | 58.3% | 0.444 |
| – 2= Fatigue | 64 | 58.7% | 35 | 72.9% | 46 | 65.7% | 5 | 71.4% | 7 | 70.0% | 25 | 83.3% | 88 | 81.5% | 0.010 |
| – 3= Fever | 53 | 48.6% | 24 | 50.0% | 42 | 60.0% | 4 | 57.1% | 6 | 60.0% | 21 | 70.0% | 71 | 65.7% | 0.136 |
| – 4= Chills | 21 | 19.3% | 8 | 16.7% | 10 | 14.3% | 0 | 0.0% | 3 | 30.0% | 9 | 30.0% | 34 | 31.5% | 0.048 |
| – 5= Headache | 46 | 42.2% | 26 | 54.2% | 39 | 55.7% | 2 | 28.6% | 4 | 40.0% | 17 | 56.7% | 62 | 57.4% | 0.222 |
| – 6= Nausea/Vomiting | 8 | 7.3% | 5 | 10.4% | 10 | 14.3% | 0 | 0.0% | 1 | 10.0% | 2 | 6.7% | 15 | 13.9% | 0.580 |
| – 7= Joint/Bone pain | 39 | 35.8% | 18 | 37.5% | 25 | 35.7% | 4 | 57.1% | 3 | 30.0% | 9 | 30.0% | 60 | 55.6% | 0.025 |
| – 8= Others | 6 | 5.5% | 1 | 2.1% | 5 | 7.1% | 0 | 0.0% | 0 | 0.0% | 4 | 13.3% | 7 | 6.5% | 0.483 |
| **Symptoms of vaccination side effects started on:** | | | | | | | | | | | | | | | |
| – Vaccination day | 55 | 50.5% | 29 | 60.4% | 37 | 52.9% | 6 | 85.7% | 2 | 20.0% | 17 | 56.7% | 57 | 52.8% | 0.374 |
| – 2nd-day post-vaccination | 54 | 49.5% | 18 | 37.5% | 32 | 45.7% | 1 | 14.3% | 8 | 80.0% | 12 | 40.0% | 50 | 46.3% | |
| – 3rd-day post-vaccination | 0 | 0.0% | 1 | 2.1% | 1 | 1.4% | 0 | 0.0% | 0 | 0.0% | 1 | 3.3% | 1 | 0.9% | |
| **Duration of side effects lasted for:** | | | | | | | | | | | | | | | |
| – 1-3 days | 79 | 72.5% | 40 | 83.3% | 58 | 82.9% | 2 | 28.6% | 7 | 70.0% | 27 | 90.0% | 85 | 78.7% | **0.008** |
| – 3-5 days | 21 | 19.3% | 8 | 16.7% | 9 | 12.9% | 5 | 71.4% | 2 | 20.0% | 2 | 6.7% | 14 | 13.0% | |
| – > 5 days | 9 | 8.3% | 0 | 0.0% | 3 | 4.3% | 0 | 0.0% | 1 | 10.0% | 1 | 3.3% | 9 | 8.3% | |

Bold values are significant at p<0.05.

**Regarding the vaccinated participants:**

A total of 1291 (848 females) participants had COVID-19 infection with COVID-19. Many of them were in the age group of 18 to 39 years (89.4%). 58.9% of them were students. 92.1% of them followed the preventive measures during the COVID-19 pandemic. Wearing a mask was the most frequently used preventive measure during the COVID-19 pandemic (94.8%) followed by hand hygiene (87.4%). 42.2% of them received the Influenza vaccine during the COVID-19 pandemic.

Of the vaccinated participants, 92.3% reported that they suffered from COVID-19 symptoms. Regarding the COVID-19 symptoms, 78.5% suffered from fever, 63.6% complained of cough, 60.7% had myalgia/body aches, and 55.4% had headache. 12.8% of the participants needed hospital admission and 6.7% needed ICU admission. Moreover, 15.4% needed oxygen inhalation and 7.5% needed mechanical ventilation. Regarding COVID-19 reinfection, 29.2% were reinfected with COVID-19 infection and 92.7% of them suffered from COVID-19 symptoms.

**Regarding the non-vaccinated participants:**

A total of 502 (403 females) participants had COVID-19 infection with COVID-19. Many of them were in the age group of 18 to 39 years (87.8%). 64.3% of them were students. 82.5% of them followed the preventive measures during the COVID-19 pandemic. Wearing a mask was the most frequently used preventive measure during the COVID-19 pandemic (95.7%) followed by hand hygiene (90.6%). 7.8% of them received the Influenza vaccine during the COVID-19 pandemic.

Of the non-vaccinated participants, 95.3% reported that they suffered from COVID-19 symptoms. Regarding the COVID-19 symptoms, 80.9% suffered from fever, 69.1% complained of cough, 62.3% had myalgia/body aches, and 56.8% had headache. 14.8% of the participants needed hospital admission and 5.6% needed ICU admission. Moreover, 18.5% needed oxygen inhalation and 6.2% needed mechanical ventilation. Regarding COVID-19 reinfection, 29.4% were reinfected with COVID-19 and 92% of them suffered from COVID-19 symptoms.

Table 6 shows a Comparison between vaccinated and non-vaccinated participants.

**Table 6: Comparison between vaccinated and non-vaccinated participants**

| | Vaccinated | | Non vaccinated | | P value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| **Age** | | | | | |
| – 0-17y | 8 | 0.6% | 3 | 0.6% | 0.804 |
| – 18-39y | 1154 | 89.4% | 441 | 87.8% | |
| – 40-59y | 119 | 9.2% | 53 | 10.6% | |
| – 60y or more | 10 | 0.8% | 5 | 1.0% | |
| **Sex** | | | | | |
| – Males | 443 | 34.3% | 99 | 19.7% | **< 0.001** |
| – Females | 848 | 65.7% | 403 | 80.3% | |
| **Type of Healthcare Worker** | | | | | |
| – Student | 760 | 58.9% | 323 | 64.3% | **0.008** |
| – Nurse/Nurse aid | 109 | 8.4% | 41 | 8.2% | |
| – Resident | 122 | 9.5% | 32 | 6.4% | |
| – Staff | 245 | 19.0% | 74 | 14.7% | |
| – Lab tech/Chemist | 16 | 1.2% | 16 | 3.2% | |
| – Radiology Technician | 6 | 0.5% | 2 | 0.4% | |
| – Worker | 19 | 1.5% | 11 | 2.2% | |
| – Administrative | 14 | 1.1% | 3 | 0.6% | |
| **Presence of Risk Factors for COVID-19 infection** | | | | | |
| – Yes | 323 | 25.0% | 117 | 23.3% | 0.449 |
| – No | 968 | 75.0% | 385 | 76.7% | |
| **Type of Risk Factors** | | | | | |
| – 1= Chronic chest disease | 123 | 38.3% | 41 | 35.3% | 0.571 |
| – 2= Cardiac disease | 63 | 19.6% | 24 | 20.7% | 0.806 |
| – 3= Obesity | 85 | 26.5% | 37 | 31.9% | 0.265 |
| – 4= Immunodeficiency | 106 | 33.0% | 35 | 30.2% | 0.574 |
| – 5= DM | 61 | 19.0% | 31 | 26.7% | 0.080 |
| – 6= kidney disease | 29 | 9.0% | 8 | 6.9% | 0.478 |
| – 7= Liver disease | 27 | 8.4% | 8 | 6.9% | 0.606 |
| – 8= Hypothyroidism | 33 | 10.3% | 13 | 11.2% | 0.780 |
| – 9= Malignancy | 35 | 10.9% | 9 | 7.8% | 0.335 |
| – 10= Chemotherapy | 33 | 10.3% | 8 | 6.9% | 0.284 |
| – 11= Others | 102 | 31.9% | 20 | 17.2% | **0.003** |
| **Compliance to preventive measures during COVID-19 pandemic** | | | | | |
| – Yes | 1189 | 92.1% | 414 | 82.5% | **< 0.001** |
| – No | 102 | 7.9% | 88 | 17.5% | |
| **Type of Preventive measures during COVID-19 pandemic** | | | | | |
| – 1= Physical distance | 929 | 78.2% | 346 | 83.4% | **0.024** |
| – 2= Wearing mask | 1126 | 94.8% | 397 | 95.7% | 0.478 |
| – 3= Hand hygiene | 1038 | 87.4% | 376 | 90.6% | **0.079** |
| **History of Influenza Vaccination during COVID-19 pandemic** | | | | | |
| – Yes | 545 | 42.2% | 39 | 7.8% | **< 0.001** |
| – No | 746 | 57.8% | 463 | 92.2% | |
| **COVID-19 first-time infection** | | | | | |
| – Yes | 662 | 51.3% | 170 | 33.9% | **< 0.001** |
| – No | 629 | 48.7% | 332 | 66.1% | |
| **Infection period** | | | | | |
| – Mar 2020- Feb 2021 | 270 | 40.8% | 74 | 43.5% | 0.752 |

| | Vaccinated | | Non vaccinated | | P value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| – Mar 2021- Nov 2021 | 253 | 38.2% | 64 | 37.6% | |
| – Dec 2021- Feb 2022 | 139 | 21.0% | 32 | 18.8% | |
| **Symptoms of COVID-19 infection** | | | | | |
| – Yes | 611 | 92.3% | 162 | 95.3% | 0.174 |
| – No | 51 | 7.7% | 8 | 4.7% | |
| **Symptoms of COVID-19** | | | | | |
| – 1= Fever | 479 | 78.5% | 131 | 80.9% | 0.516 |
| – 2= Runny nose | 307 | 50.3% | 75 | 46.3% | 0.362 |
| – 3= Cough | 388 | 63.6% | 112 | 69.1% | 0.190 |
| – 4= Wheezing | 107 | 17.5% | 45 | 27.8% | **0.004** |
| – 5= Shortness of breath | 232 | 38.0% | 66 | 40.7% | 0.529 |
| – 6= Chest pain | 154 | 25.2% | 60 | 37.0% | **0.003** |
| – 7= Loss of taste | 338 | 55.4% | 84 | 51.9% | 0.419 |
| – 8= Loss of smell | 367 | 60.2% | 97 | 59.9% | 0.947 |
| – 9= Nausea/vomiting | 84 | 13.8% | 28 | 17.3% | 0.529 |
| – 10= Abdominal pain/Diarrhea | 142 | 23.3% | 39 | 24.1% | 0.832 |
| – 11= Headache | 338 | 55.4% | 92 | 56.8% | 0.753 |
| – 12= Myalgia/Body aches | 370 | 60.7% | 101 | 62.3% | 0.695 |
| – 13= Sore throat | 321 | 52.6% | 75 | 46.3% | 0.152 |
| – 14= Pink eyes | 61 | 10.0% | 22 | 13.6% | 0.191 |
| – 15= Rash | 20 | 3.3% | 7 | 4.3% | 0.523 |
| **Need for Hospital admission** | | | | | |
| – Yes | 78 | 12.8% | 24 | 14.8% | 0.493 |
| – No | 533 | 87.2% | 138 | 85.2% | |
| **Need for ICU admission** | | | | | |
| – Yes | 41 | 6.7% | 9 | 5.6% | 0.595 |
| – No | 570 | 93.3% | 153 | 94.4% | |
| **Need for Oxygen** | | | | | |
| – Yes | 94 | 15.4% | 30 | 18.5% | 0.334 |
| – No | 517 | 84.6% | 132 | 81.5% | |
| **Need for mechanical ventilation** | | | | | |
| – Yes | 46 | 7.5% | 10 | 6.2% | 0.554 |
| – No | 565 | 92.5% | 152 | 93.8% | |
| **COVID-19 Reinfection** | | | | | |
| – Yes | 193 | 29.2% | 50 | 29.4% | 0.947 |
| – No | 469 | 70.8% | 120 | 70.6% | |
| **Infection period** | | | | | |
| – Mar 2020- Feb 2021 | 60 | 31.1% | 12 | 24.0% | 0.328 |
| – Mar 2021- Nov 2021 | 63 | 32.6% | 19 | 38.0% | 0.475 |
| – Dec 2021- Feb 2022 | 87 | 45.1% | 23 | 46.0% | 0.907 |
| **Symptoms of COVID-19 infection** | | | | | |
| – Yes | 179 | 92.7% | 46 | 92.0% | 0.770 |
| – No | 14 | 7.3% | 4 | 8.0% | |
| **Symptoms of COVID** | | | | | |
| – 1= Fever | 130 | 72.6% | 32 | 71.1% | 0.839 |
| – 2= Runny nose | 95 | 53.1% | 17 | 37.8% | 0.067 |
| – 3= Cough | 111 | 62.0% | 23 | 51.1% | 0.182 |
| – 4= Wheezing | 43 | 24.0% | 11 | 24.4% | 0.953 |
| – 5= Shortness of breath | 56 | 31.3% | 15 | 33.3% | 0.792 |
| – 6= Chest pain | 41 | 22.9% | 16 | 35.6% | 0.082 |

| | Vaccinated | | Non vaccinated | | P value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| – 7= Loss of taste | 64 | 35.8% | 23 | 51.1% | 0.059 |
| – 8= Loss of smell | 75 | 41.9% | 21 | 47.7% | 0.484 |
| – 9= Nausea/vomiting | 18 | 10.1% | 5 | 11.1% | 0.788 |
| – 10= Abdominal pain/Diarrhea | 35 | 19.6% | 11 | 24.4% | 0.468 |
| – 11= Headache | 85 | 47.5% | 31 | 68.9% | **0.010** |
| – 12= Myalgia/Body aches | 92 | 51.4% | 29 | 64.4% | 0.116 |
| – 13= Sore throat | 69 | 38.5% | 27 | 60.0% | 0.009 |
| – 14= Pink eyes | 14 | 7.8% | 3 | 6.7% | 0.794 |
| – 15= Rash | 3 | 1.7% | 2 | 4.4% | 0.265 |
| **Need for Hospital admission** | | | | | |
| – Yes | 44 | 24.6% | 4 | 8.7% | **0.019** |
| – No | 135 | 75.4% | 42 | 91.3% | |
| **Need for ICU admission** | | | | | |
| – Yes | 36 | 20.1% | 2 | 4.3% | **0.011** |
| – No | 143 | 79.9% | 44 | 95.7% | |
| **Need for Oxygen** | | | | | |
| – Yes | 48 | 26.8% | 8 | 17.4% | 0.187 |
| – No | 131 | 73.2% | 38 | 82.6% | |
| **Need for mechanical ventilation** | | | | | |
| – Yes | 35 | 19.6% | 2 | 4.3% | **0.013** |
| – No | 144 | 80.4% | 44 | 95.7% | |

Bold values are significant at p<0.05.

## DISCUSSION

The COVID-19 pandemic's emergence and rapid global spread significantly disrupted healthcare services worldwide.[13,14] Despite this, many individuals infected with the virus can remain asymptomatic while still being contagious.[15,16] Consequently, implementing primary prevention measures within communities becomes inherently challenging.[17,18] The global effort to combat the disease centered on mass vaccination campaigns. These vaccines aimed to protect individuals from coronavirus infection or developing severe symptoms by prompting their immune systems.

Throughout the pandemic, reinfections with COVID-19 have emerged as a growing concern, yet this pressing public health issue remains inadequately addressed. [19,20]

Analysis of participant demographics revealed a notable proportion within the 18-39 age group, with a majority being female. This suggests that females exhibit heightened concerns about their health and infection risk,[21] likely prompting them to share their experiences with colleagues. to produce antibodies.[22,23]

Approximately a quarter of participants possessed risk factors for COVID-19 infection, with chronic chest conditions, obesity, and immunodeficiency being the most prevalent. This aligns with previous research findings. [24,25]

Many participants demonstrated a commitment to COVID-19 preventive measures, indicating both awareness of the virus's dangers and a fear of contracting it. Reported precautions included maintaining physical distance, wearing masks, and practicing hand hygiene. These preventive measures remain crucial for safeguarding healthcare workers against the virus.[26,27]

During the COVID-19 pandemic, nearly a third of participants received the Influenza vaccine. A previous research showed a significant decrease in the odds of testing positive for COVID-19 among those who had the influenza vaccine compared to those who did not. Moreover, individuals who had received the influenza vaccine and later tested positive for COVID-19 experienced notably better clinical outcomes.[28]

Additionally, a previous study explored the impact of widespread influenza immunization on COVID-19 transmission and other respiratory infections during concurrent outbreaks. It revealed that increased vaccine uptake could aid in managing respiratory outbreaks alongside the peak influenza season and compensate for limited detection resources.[29] Furthermore, in scenarios where both influenza and SARS-CoV-2 viruses circulate, high influenza vaccine uptake, particularly in seasons where vaccine strains closely match circulating strains, could reduce the interference of influenza during the COVID-19 epidemic. [29]

PCR stands as the primary method for diagnosing COVID-19 infection in this research. This technique involves reverse transcription of the virus's genetic material (RNA) to complementary DNA (cDNA), then

amplifying certain regions of the cDNA. Probes (DNA/RNA marked sequences to detect the genetic target in the material) and primers (DNA/RNA sequences that facilitate replication of genetic material in the sample) were created following the sequencing of the SARS-CoV-2 genome. Multiple amplification cycles are conducted to identify these targets; the more cycles needed, the lower the viral load in the material being studied.[30]

Among the study population, fever, cough, and loss of taste and smell emerged as the most common symptoms of COVID-19 infection. Loss of taste and smell notably indicates a COVID-19 infection.[31,32]

In cases of reinfection examined in this study, symptoms were more severe compared to initial infection, as evidenced by higher rates of hospitalization and ICU admission. Previous research suggests that a higher initial viral load independently correlates with poorer prognosis in SARS. Hence, the adverse outcomes among SARS patients should be considered alongside factors like age, comorbidities, and viral load.[33,34]

Healthcare workers in this study exhibited heightened caution regarding vaccination, owing to their occupational exposure to COVID-19 patients, aiming to shield themselves from infection risks. This cautious approach aligns with findings by Rahul Shekhar et al. Vaccine hesitancy among the general public could exacerbate the situation, particularly for healthcare workers.[35,36]

COVID-19 vaccines have the potential to shield individuals from coronavirus infection or severe symptoms by stimulating the immune system to generate antibodies. These antibodies, post-vaccination, adhere to the invader spike protein and limit the ability of the virus to enter into the cells.[37] Most participants in the study received complete doses of COVID-19 vaccine. A previous study showed that a single dose sufficed for individuals with prior coronavirus infections to attain satisfactory antibody levels.[38]

The primary vaccines utilized in this study were Pfizer, Sinopharm, Sinovac, and AstraZeneca. However, developing immunity post-vaccination may trigger side effects, a key factor contributing to vaccine hesitancy. Raising awareness regarding vaccine efficacy and elucidating potential side effects are deemed vital for enhancing vaccine acceptance. Notably, side effects can vary depending on the vaccine type.[22]

Common post-COVID-19 vaccination side effects included fatigue, fever, pain, redness at the injection site, and headache. Post-vaccination side effects were more prevalent with the Johnson and Johnson vaccine (47.6%) followed by the Sputnik vaccine (46.7%) in this study. Pain and redness at the injection site were the most frequently reported side effects, followed by fatigue and fever.

Side effects typically manifested on the first day post-vaccination with Pfizer, Sinopharm, Sinovac, Sputnik, Johnson and Johnson, and AstraZeneca, while with Moderna, they occurred on the second day. The duration of side effects mostly spanned from 1 to 3 days post-vaccination with Pfizer, Sinopharm, Sinovac, Moderna, Johnson and Johnson, and AstraZeneca, but extended to 3 to 5 days with Sputnik.

In a prior study, it was noted that post-vaccination side effects were more frequently observed with RNA (mRNA) vaccines compared to others.[22] Individuals with severe allergies (anaphylaxis) or allergies to vaccine components are advised against vaccination due to the potential risk of allergies and skin rashes.[39,40]

Most individuals develop immunity against coronavirus post-vaccination, irrespective of experiencing side effects. A previous study showed that only one in four people experience mild and short-lived side effects after receiving COVID-19 vaccines.[41] Common side effects following vaccination, according to the World Health Organization, include fatigue, fever, headaches, injection site pain, nausea, and diarrhea, consistent with the findings of this study. [22]

Ensuring the safety and efficacy of vaccines is paramount for their widespread use in curbing virus transmission.[15]

Non-vaccinated participants in this study faced heightened risk of COVID-19 infection, experiencing more severe symptoms and increased likelihood of hospitalization. Common reasons for non-vaccination included fear, pregnancy, and lactation. Disseminating knowledge about post-vaccination outcomes among the general population, particularly among healthcare workers, could enhance awareness and health education regarding COVID-19 vaccines. Fear, rumors, and lack of comprehensive clinical trial information are cited as factors contributing to vaccine hesitancy.[42,43]

## CONCLUSIONS

Healthcare Workers (HWs) face a heightened risk of both initial infection and reinfection, with symptoms often more severe upon reinfection, leading to increased rates of hospitalization and ICU admissions. AstraZeneca, Pfizer, Sinopharm, and Sinovac were the most commonly administered vaccines in this study. Non-vaccinated participants faced elevated risks of contracting COVID-19, experiencing more severe symptoms, and requiring increased hospitalization. The most prevalent post-COVID-19 vaccination side effects included fatigue, fever, injection site pain and redness, and headache. Side effects were more commonly reported following administration of the Johnson and Johnson and Sputnik vaccines. The side effects appeared within the first day post-vaccination and mostly lasted for 1 to 3 days post-vaccination.

**Recommendation:**

- Vaccination is the most effective strategy for managing the pandemic.
- Comprehensive data on reinfection rates and risk factors are still limited so needs further studies.
- Healthcare workers are at high risk of exposure so proper care is recommended.

**Declarations**

*Ethics approval and consent to participate*

This study acquired an approval letter from the Research Ethics Committee (REC) of the Faculty of Medicine, Cairo University under the reference number N-487-2023. Informed consent to participate was obtained from all individual participants older than the age 16. Participants younger than the age of 16, consent to participate was obtained from their legal guardians. All methods were performed in accordance with the relevant guidelines and regulations.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Competing interests**

The authors declare no competing interests (including financial and personal nature).

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**Authors' contributions**

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [H.S.], [R.M.], [S.E.], [H.A.], [R.A.], [S.B.] , [G.H.], [R.M.], [M.A.], [S.M.K.], [S.M.M.], [A.M.A.E.], , and [A.M.A.]. The first draft of the manuscript was written by [M.O.]and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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