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Evaluation of symptoms, hematological parameter and antibodies levels among two COVID-19 vaccines recipients and control groups

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Abstract:

Background: SARS-CoV-2 infection causes high rates of infection and death worldwide, constituting a widespread global pandemic and representing a major public health problem. While COVID-19 vaccines are known to reduce the severity of symptoms, comparative data on vaccine types in Iraq remains limited. **objective:** The present study aims to estimate and evaluation of symptoms, hematological parameter and antibodies levels among two COVID-19 vaccines recipients and control groups in Basrah populations. **Methodology:** A total of 277 individuals of both sexes' adults recruited from Al-Mudaina General Hospital between November 2021 and April 2022., comprising 153 individuals as vaccinated group, 62 of them are males and 91 females with age range 18 years - 78 years, furthermore, 124 individuals as unvaccinated group, 60 of them are males and 64 females with age range 18 years-77 years, were selected Vaccinated participants received either the Pfizer vaccine (n = 117) or the Sinopharm vaccine (n = 36). Clinical symptoms, hematological parameters (white blood cell count and lymphocyte count), and IgG/IgM antibodies against SARS-CoV-2 were assessed. Polymerase chain reaction (PCR) testing was performed on symptomatic individuals. Statistical analysis included t-tests, chi-squared tests, and logistic regression, adjusting for age and sex. Results were considered statistically significant at a p-value of less than 0.05. randomly. **Results:** The present study showed clear significant differences between symptoms in the two studied groups. The symptoms of the disease were more among individuals in the unvaccinated group than in the individuals that received

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vaccines after dose 2 in vaccinated group. Hematological parameter levels were measured among studied groups. The present results showed that there were significant differences (P< 0.05) in the levels of hematological parameters between the first and second doses within the same vaccine. COVID-19 antibodies levels were measured among vaccinated group. In general, anti-SARS-2 IgG antibodies levels had more significant than anti-SARS-2 IgM antibodies among vaccinated group. Vaccination reduced symptoms after SARS-COV-2 infection. **Conclusions:** Vaccination is associated with lower rates of SARS-CoV-2 infection and reduced symptom severity. While Pfizer and Sinopharm vaccines elicited humoral immune responses, protection cannot be directly inferred from antibody levels alone. Given the observational nature of the study, the findings should be interpreted as correlations, not causal inferences.
Keywords: COVID-19 vaccines, Pfizer vaccine, Sinopharm vaccine, hematological parameter.

Introduction

Chinese health authorities confirmed that these cases were associated with a novel coronavirus, which was subsequently named 2019¬nCoV by World Health Organization (WHO) [1]. As a total of 44 incidents had been registered by the Chinese government as of 3 January 2020 WHO has received reports of cases of pneumonia in which the etiology has not been identified. A confirmed outbreak has not yet occurred [2]. On March 11, 2020, the WHO declared a global pandemic due to the rapid spread of the new SARS 2 virus that first surfaced in Wuhan, China in December of this year and quickly spread [3]. The first case of SARS-COV-2 infection in Iraq was identified on February 24th, when an Iranian visitor to Najaf governorate became afflicted. New instances are being reported by the Ministry of Health on a nearly daily basis, due to the initial influx of imported illnesses [4]. Misconceptions concerning SARS-CoV2 in Iraq in general, and particularly in Basrah governorate, people aren't taking the essential precautions to avoid infection by wearing masks and gloves, which is a major factor in the pandemic [5]. SARS COV-2 infection has caused a large number of people to become ill and die in Iraq, putting us in the position of having to investigate and uncover the secrets of this new virus and the role that immunity (innate or acquired) plays in combating it [6]. As a result of the BNT162b2 mRNA COVID-19 vaccine from Pfizer and BioNTech, 95% effectiveness was demonstrated against laboratory-confirmed

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COVID-19 [7]. So, the present study aims to estimate and evaluation of symptoms, hematological parameter and antibodies levels among two COVID-19 vaccines recipients and control groups in Basrah populations.

Materials and Methods

Subjects

The present cross-sectional analytical observational study was conducted on the following study groups during the period November 2021 into April 2022. The Al-Mudaina district was chosen as the study area, and Al-Mudaina general hospital to conduct the tests for the present study. A total of 277 individuals of both sexes, comprising 153 individuals as vaccinated group, 62 of them are males and 91 females with age range 18 years - 78 years, furthermore, 124 individuals as unvaccinated group, 60 of them are males and 64 females with age range 18 years-77 years, were selected randomly.

Study design and participants

Selection of cases and matched controls cases were selected from the study population who had a SARS-CoV-2 infection, defined as a positive SARS-CoV-2 real time-PCR test result from a respiratory sample that was collected during the study period and the absence of a positive test in the preceding 90-day period [8]. **Inclusion criteria** included Persons aged ≥18 years**,** No history of a confirmed SARS-CoV-2 infection**,** No history (14 days) of respiratory symptoms. **Exclusion criteria** included Chronic diseases with compromise of immunity**,** Prior COVID-19 vaccination other than the two vaccines being investigated**,** Poor vaccination records

Study Groups: involved Vaccinated cohort: 153 adults; f Pfizer n=117, Sinopharm n=36 **and** 124 adults in the unvaccinated control group

Vaccination status

Vaccinated participants received either Pfizer (n=117) or Sinopharm (n=36). Clinical symptoms, hematological parameters (WBCs, lymphocytes), and IgG/IgM antibodies against SARS-CoV-2 were assessed. Vaccination date, type, and manufacturer, all participants were collected. Participants with incomplete vaccination history (e.g., missing or invalid doses, non-valid vaccination dates, etc.) were recorded.

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Collection of samples

A sample of 5 ml blood was collected by vein puncture; a 2ml of blood was put in EDTA tube used for measurement of hematological parameters for each individual in the studied and control groups. The remaining of blood was put in gel tube for measuring the levels of COVID-19 IgG and IgM antibodies for each individual who received one or two doses of the two vaccines in the studied group. Furthermore, nasal swab was taken from each individual who shows symptoms of infection with the virus to confirm or deny infection using a real-time PCR technique.

Molecular detection of SARS-CoV-2 by real time-PCR technique

As a result of the follow-up of the two study groups, any individual showing any symptoms of respiratory infection, nasal swab samples were sent to the authorized laboratories of the health department in Qurna hospital for detection of SARS-CoV-2 by real time-PCR technique.

Hematological parameter

An automatic hematology analyzer (Mindery bc 5000, china) was used to measure total white blood cells (WBCs) and lymphocytes, five par to estimate numbers and percentages of white blood cells.

Measurement of COVID-19 antibodies levels

Ichroma ™ COVID-19 antibodies were used to measure IgG/IgM antibodies against 'Novel Coronavirus' in human whole blood /serum/ plasma.

Statistical analysis

Analysis of the data obtained was made by using SSPS software version SPSS 24. P values <0.05 were considered statistically significant. Frequencies of each group were calculated by direct counting. Chi squares, t-test/Mann–Whitney for two-group continuous comparisons, ANOVA/Kruskal–Wallis for more than two groups were performed to indicate the significant differences between groups. Baseline characteristics in the vaccinated and unvaccinated groups were described using proportions. Logistic regression to adjust for confounders (age, sex) Effect sizes with 95% confidence intervals reported. Significance threshold: P<0.05

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Results

Characterization of study population

A total of 277 individuals were divided into 2 studied groups, vaccinated group and unvaccinated group, gives up (Table,1) the follows percentages (No., %). The current results showed that the numbers and percentages of sexes vaccinated with the Pfizer vaccine were significantly higher than those vaccinated with the Sinopharm vaccine. One of the unexpected results was that females (72, 61.53%) that received vaccine were significantly more ($P < 0.016$) than males (45, 38.47%) within the Pfizer vaccine (Figure, 1). Furthermore, the age ranges among vaccinated group varied between 18 and 90 years, while, the age ranges among unvaccinated group varied between 18 and 77 years. The age groups were divided into 5 age periods. The age period between (18-29) which has individuals that received vaccine among vaccinated group was more significant ($P< 0.05$) than other periods in the same group. In contrast, the age periods (50-59) and (≥ 60) years were significantly decreased ($P< 0.05$) from individuals that received vaccine. In contrast, there were less or no significant of age periods among individuals that received Sinopharm vaccine.

In general, there was a clear and significant response for individuals to receive the Pfizer vaccine than Sinopharm vaccine.

Table (1) Characteristics of studied groups

Parameters	Vaccinated group			Unvaccinated group	
	Pfizer	Sinopharm	*P value*		*P value*
Sex					
Males	45 (38.47%)	17 (47.23%)	0.329	60 (48.39%)	0.918
Females	72 (61.53%)	19 (52.77%)	0.401	64 (51.61%)	0.922
Total	117 (100%)	36 (100%)		124 (100%)	
P value	0.016	0.549		0.689	
Age groups					
18-29	67 (43.79%)	15 (9.80%)	0.132	25 (20.16%)	0.000
30-39	25 (16.34%)	11 (7.19%)	0.166	31 (25%)	0.541
40-49	17(11.11%)	4 (2.62%)	0.231	28 (22.58%)	0.696
50-59	5 (3.27%)	3 (1.96%)	0.248	26 (20.97%)	0.002
≥ 60	3 (1.96%)	3 (1.96%)	0.132	14 (11.29%)	0.074
Total	117 (100%)	36 (100%)		124 (100%)	
P value ≤ 0.05					

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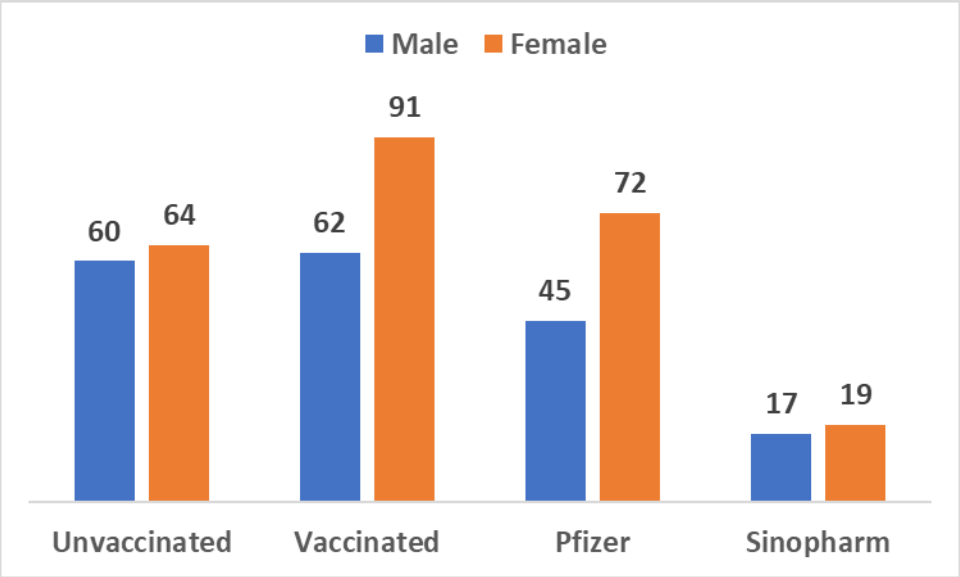

Figure (1) sex distribution among studied groups

PCR positive of SARS-CoV-2 among studied groups

It is worth noting that the positive infections with the virus occurred after the second dose only. The results of the follow-up of the two studied groups showed that the percentages of PCR positive (Table, 2) of SARS-CoV-2 among unvaccinated group were 74/124(59.67%) highly significant than vaccinated group (18/153;11.76%) at P Value 0.000, where the results of the negative PCR in the vaccinated group had significantly higher than unvaccinated group (Figure, 2 and 3). Among two vaccines, individuals that received Pfizer vaccine showed significantly decreased (P< 0.00) in PCR positive results of SARS-CoV-2. Furthermore, the sex results showed clear significant between males and females. In general, females (12, 66.67%) that received vaccine were significantly more (*P* Value 0.001) than males (6, 33.33%) in infection with SARS-CoV-2.

Table (2) distribution of SARS-CoV-2 PCR +ve among studied groups

Groups	No.	Total		Sex		Hospitalization
				Male	Female	
		PCR +ve	PCR -ve	PCR +ve	PCR +ve	
Unvaccinated	124	74 (59.67%)	50 (40.33%)	32 (43.23%)	42 (56.77%)	48 (64.86%)
P value		0.031		0.162		
Vaccinated	153	18 (11.76%)	135 (88.24%)	6 (33.33%)	12 (66.67%)	2 (11.12%)

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***P* value**		**0.000**		**0.001**		
Pfizer	**117**	**13 (11.12%)**	**104 (88.88%)**	**3 (23.08%)**	**10 (76.92%)**	**1 (7.69%)**
***P* value**		**0.000**		**0.000**		
Sinopharm	**36**	**5 (13.88%)**	**31 (86.12%)**	**3 (60%)**	**2 (40%)**	**1 (20%)**
***P* value**		**0.000**		**0.046**		

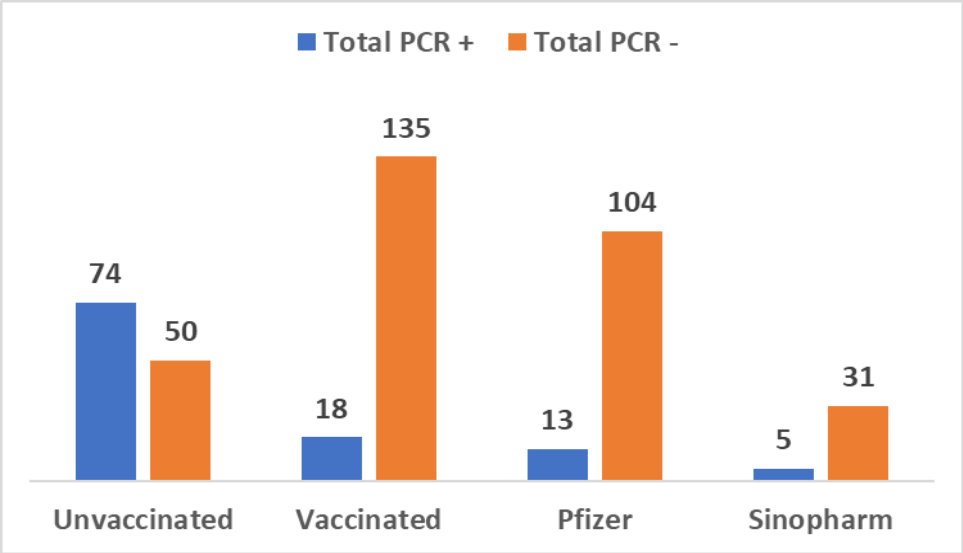

Figure (2) distribution of SARS-CoV-2 PCR results among studied groups

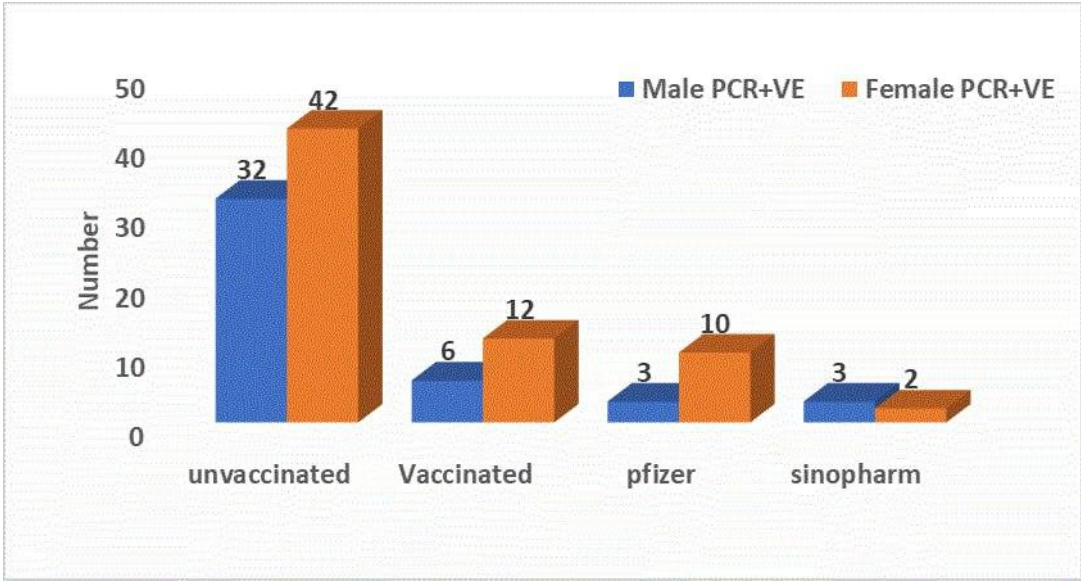

Figure (3) distribution of sex among SARS-CoV-2 PCR results of studied groups

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Symptoms of Covid19 infections

The present study showed clear significant differences (Table, 3; Figure, 4) between symptoms in the two studied groups. The symptoms of the disease were more among individuals in the unvaccinated group than in the individuals that received vaccines after dose 2 in vaccinated group. Regarding the fever, there were high significant differences between the individuals that received vaccines (12/ 66.67%) compared to the unvaccinated group (57/77.02%) at *P* value= 0.405. With the same previous result, the most important symptoms in Covid19 infections, such as fatigue, headache, shortness of breath, cough, runny nose and sneeze were high significant differences between two studied groups. Interestingly, the age periods between (40-49) and (50-59) years had more significant (P< 0.05) than other periods regarding symptoms. In contrast, the age periods (30-39) years was significantly decreased (P< 0.05) than other periods regarding symptoms.

Table (3) symptoms of COVID-19 in unvaccinated and vaccinated groups after dose 2

Age intervals	No.	symptomatic disease								
		Fever	Fatigue	Headache	Chills	Sore throat	Shortness of breath	Cough	Runny nose & sneeze	Diarrhea
Unvaccinated group										
18-29	14	10	8	8	2	8	0	9	6	0
30-39	12	9	9	7	5	7	2	7	4	1
40-49	16	12	13	12	9	10	2	9	9	1
50-59	22	18	15	18	9	16	8	15	11	5
≥ 60	10	8	9	9	3	5	6	8	3	2
Total	74 100%	57 77.02%	54 72.97%	54 72.97%	28 37.83%	46 62.16%	18 24.32%	48 64.86%	33 44.59%	9 12.16%
vaccinated group										
18-29	6	3	0	4	0	4	0	4	2	0
30-39	4	3	1	3	1	2	0	3	3	0
40-49	2	2	0	1	1	1	0	2	1	0

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50-59	2	1	1	2	1	1	0	1	2	1
≥ 60	4	3	2	3	2	2	2	3	3	2
Total	18 100%	12 66.66%	4 22.22%	13 72.22%	5 27.77%	10 55.55%	2 11.11%	13 72.22%	11 61.11%	5 16.66%
P value	0.000	0.405	0.000	0.934	0.218	0.581	0.028	0.493	0.012	0.353

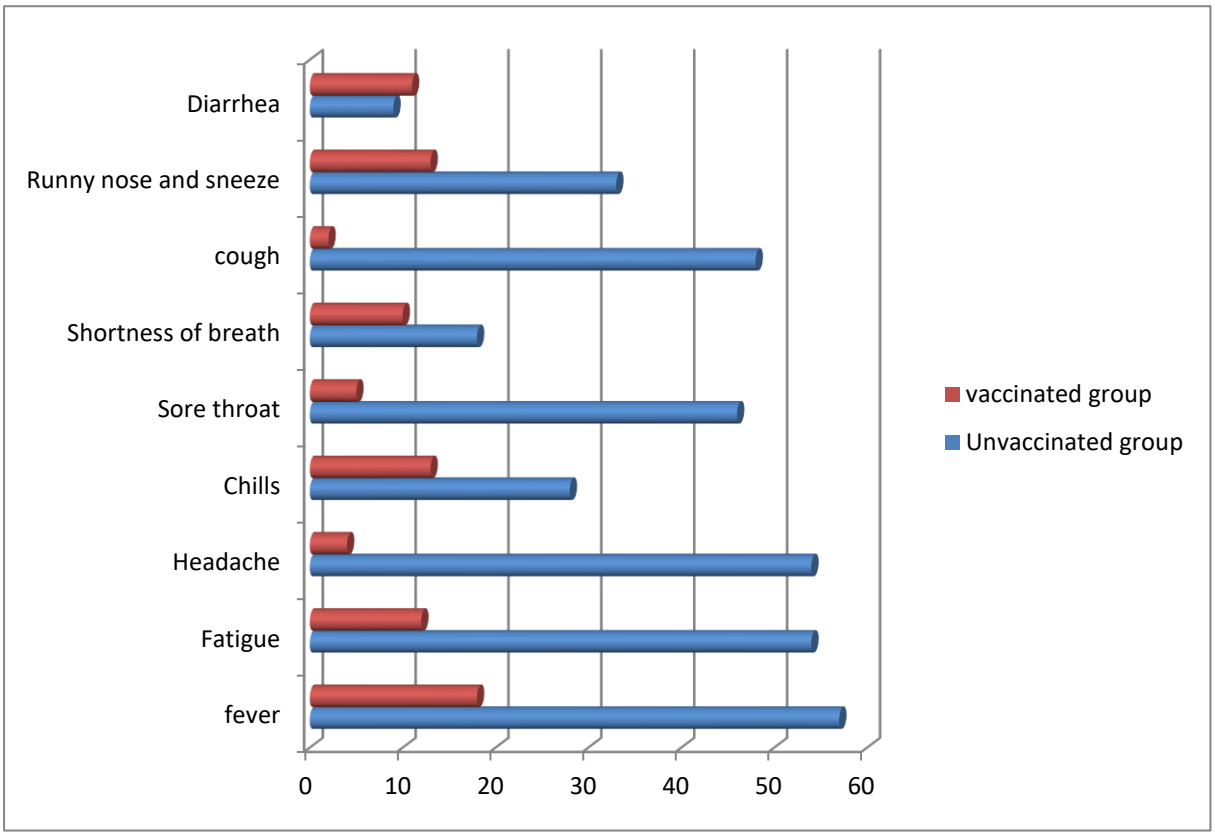

Figure (4) symptoms of COVID-19 in unvaccinated and vaccinated groups after dose 2

As shown in the table, 4 and figure, 5, the most important symptoms in Covid19 infections were fever, headache, sore throat and runny nose with significant differences between two studied vaccines. Where it was possible to conclude that the Pfizer vaccine gives more immunity compared to the Sinopharm vaccine, so that the symptoms were less severe and appearance among the infected individuals after the vaccine. According to the numbers among the infected individuals within the Sinopharm vaccine, 100% of the individuals showed fever, headache and runny nose.

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Table (4) symptoms of COVID19 in Pfizer and Sinopharm vaccines after dose 2

Age intervals	No.	PCR +ve	Symptomatic disease								
			Fever	Fatigue	Headache	Chills	Sore throat	Shortness of breath	Cough	Runny nose & sneeze	Diarrhea
Pfizer vaccine											
18-29	67	5	2	0	3	0	3	0	3	1	0
30-39	25	2	1	0	1	0	1	0	1	1	0
40-49	17	2	2	0	1	1	1	0	2	1	0
50-59	5	1	0	1	1	0	0	0	1	1	0
≥ 60	3	3	2	3	2	1	1	1	2	2	2
Total	117	13	7 53.84 %	4 30.76%	8 61.53%	2 15.38 %	6 46.15 %	1 7.69%	9 69.23 %	6 46.15 %	2 15.38%
Sinopharm vaccine											
18-29	15	1	1	0	1	0	1	0	1	1	0
30-39	11	2	2	1	2	1	1	0	2	2	0
40-49	4	0	0	0	0	0	0	0	0	0	0
50-59	3	1	1	0	1	1	1	0	0	1	1
≥ 60	3	1	1	1	1	1	1	1	1	1	0
Total	36	5	5 100 %	2 40%	5 100%	3 60%	4 80%	1 20%	4 80%	5 100%	3 60%
P value	0.000	0.059	0.000	0.285	0.003	0.000	0.002	0.023	0.368	0.000	0.000

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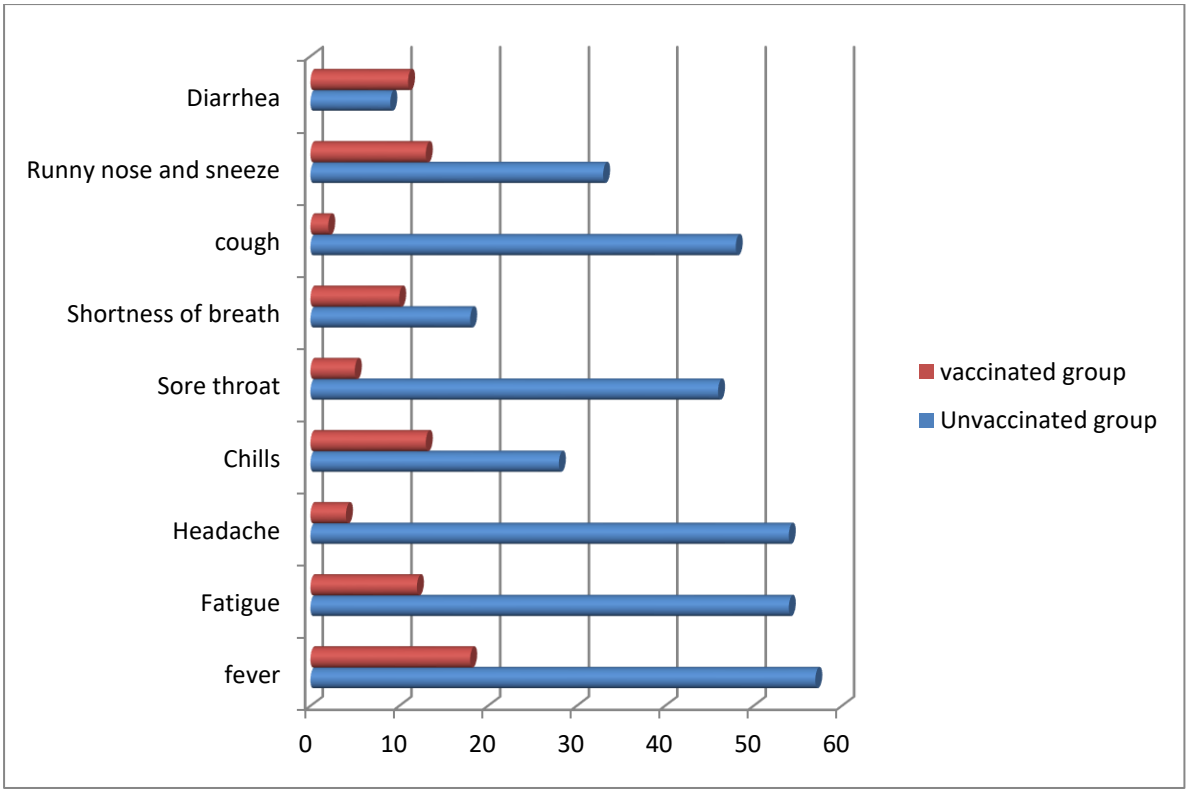

Figure (5) symptoms of COVID19 in Pfizer and Sinopharm vaccines after dose 2

Regarding the time intervals (in days) during which infection and symptoms appeared after the second dose of the studied vaccines, the results showed that the period after ≥14 days was the period with the highest percentage of infections as shown in the table, 5. Also, the Pfizer vaccine had clear significant differences compared to the Sinopharm vaccine.

Table (5) PCR +ve of COVID-19 infections that appeared after dose 2 (in days)

Vaccines	PCR+ve			
	Time intervals (in days)			
	0-3	4-6	7-13	≥14
Pfizer	0	0	1 (7.7%)	12 (92.3%)
Sinopharm	0	0	1 (20%)	4 (80%)
P value	-	-	0.023	0.360

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Hematological parameter

Hematological parameter levels (Mean ± SD) were measured among studied groups as shown in table 6. The present results showed that there were significant differences (P< 0.05) in the levels of hematological parameters between the first and second doses within the same vaccine. While the results showed that there were significant differences (P< 0.05) between Pfizer and Sinopharm vaccines among WBC within the dose 2. Regarding the lymphocyte, no significant differences appeared between the two studied vaccines. However, there were clear significant differences between the vaccines and the control group.

Measurement of COVID-19 antibodies levels

COVID-19 antibodies levels (Mean ± SD) were measured (Table, 7) among vaccinated group. In general, anti-SARS-2 IgG antibodies levels (Mean ± SD) had more significant than anti-SARS-2 IgM antibodies among vaccinated group. Regarding the anti-SARS-2 IgG antibodies levels (48.460±15.1731) had highly significant (P< 0.000) than anti-SARS-2 IgM antibodies (0.7354±0.82309) among individuals that received Pfizer vaccine. Also, individuals that received Sinopharm vaccine showed highly significant (46.819±19.1056) of anti-SARS-2 IgG antibodies levels than anti-SARS-2 IgM antibodies (0.6639±0.87281) at *P* value = 0.000. While there were no significant differences between the two studied vaccines in the production of antibodies type IgM and IgG.

Table (6) Hematological parameter of studied groups

Vaccines	Parameters	Min.-Max. Cell/L (x 10^9)	Mean ±SD
Pfizer	WBC dose 1	3.5 -33.9	7.7329±1.99179
	WBC dose 2	3.59 -12.78	8.4236±3.29566
	P value = 0.003		
	Lymphocyte dose 1	.,8 -8.9	3.1213±0.93847
	Lymphocyte dose 2	1.03× -7.8	2.7852±1.06547
	P value = 0.011		
Sinopharm	WBC dose 1	4.3 -14.8	7.2428±1.48736
	WBC dose 2	4.44 -9.89	7.7175±1.97681
	P value = 0.254		
	Lymphocyte dose 1	1.4 -4.9	2.8922±0.68199

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	Lymphocyte dose 2	1.7 -4.19	2.4175±0.77639
	P value = 0.007		
Unvaccinated	WBC	1.94-12.9	6.724274±2.452105
	Lymphocyte	1.1-3.9	2.366129±0.543146
Parameters		*P* value	
WBC	Pfizer dose1 &Sinopharm dose 1	0.175	
	Pfizer dose2 &Sinopharm dose 2	0.009	
	All vaccinated &Unvaccinated	0.000	
Lymphocyte	Pfizer dose1 &Sinopharm dose 1	0.177	
	Pfizer dose2 &Sinopharm dose 2	0.057	
	All vaccinated &Unvaccinated	0.000	

Table (7) COVID-19 antibodies levels among vaccinated group

Vaccines	Parameters	Min.-Max.	Mean ±SD	*P* value
Pfizer	Anti-SARS-2 IgG	0.5-101.9	48.460±15.1731	0.595
	Anti-SARS-2 IgM	0.1-5.7	0.7354±0.82309	0.654
P value = 0.000				
Sinopharm	Anti-SARS-2 IgG	2.2-91.1	46.819±19.1056	0.595
	Anti-SARS-2 IgM	0.0-4.9	0.6639±0.87281	0.654
P value = 0.000				

Discussion

Characterization of study population

On 30 January 2020, the WHO declared COVID-19 as the sixth public health emergency of international concern. SARS-CoV-2 is closely related to two bat-derived severe acute respiratory syndrome-like coronaviruses, bat-SL-CoVZC45 and bat-SL-CoVZXC21 [9]. SARS-2 has caused a large global outbreak and is a major public health issue [10].

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A total of 277 individuals were divided into 2 studied groups, vaccinated group and unvaccinated group, gives up (Table, 1) the follows percentages (No., %). The current results showed that the numbers and percentages of sexes vaccinated with the Pfizer vaccine were significantly higher than those vaccinated with the Sinopharm vaccine. One of the unexpected results was that females (72, 61.53%) that received vaccine were significantly more ($P < 0.016$) than males (45, 38.47%) within the Pfizer vaccine.

Anyone ages 16 and older, Infants, children, and teenagers ages 6 months to 15 years are eligible. For the primary series: two shots, 3-8 weeks apart. Dosages for infants and children are different than those for adults. Most adults should get an updated Pfizer-BioNTech or Moderna bivalent booster at least 2 months after their primary series. Infants as young as 6 months, children, and teenagers are also eligible for the Pfizer bivalent booster. The bivalent boosters authorized in August 2022 are designed to protect against disease caused by the original strain of the SARS-CoV-2 virus, as well as Omicron variants BA.4 and BA.5. Adults who are immunocompromised can choose between the three available vaccines, following a schedule similar to immunocompromised teens. Possible side effects: Pain, redness, or swelling at the site where the shot was administered, and/or tiredness, headache, muscle pain, chills, fever, or nausea throughout the rest of the body. If these side effects occur, they should go away in a few days. A few side effects are serious, but rare. These include anaphylaxis, a severe reaction that is treatable with epinephrine [11].

PCR positive of SARS-CoV-2 among studied groups and symptoms of Covid19 infections

Most vaccines reduce, or likely reduce, the proportion of participants with confirmed symptomatic COVID-19, and for some, there is high-certainty evidence that they reduce severe or critical disease. There is probably little or no difference between most vaccines and placebo for serious adverse events. In the ongoing SARS-CoV-2 pandemic, a subunit vaccine (NVX-CoV2373) has been developed using a full-length glycoprotein and administered with adjuvant Matrix-M in non-human rat and monkey models, inducing B- and Th1-dependent Th1-induction [12]. T-cell responses, production of hACE2 receptor-blocking antibodies, and SARS-CoV-2 neutralizing antibodies. No vaccine-related adverse effects were reported in mouse models, which encouraged further clinical development of NVX-CoV2373 against COVID-19 [13].

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Hematological parameter and measurement of COVID-19 antibodies levels

The researchers created a modified SARS-CoV-2 "spiky gene" and installed it in the bacterial virus, which can only infect insects. Hence, selective moth cells were selected and infected with recombinant baculovirus. As a result, the infected cell began to produce spike proteins that aggregate to form a full-length spike protein similar to SARS-CoV-2 [14]. Then, the spike proteins were purified and fixed with nanoparticles, which were used as inoculum. Before being mixed with adjuvant distilled from soap bark plants, this vaccine attracts immune cells to the injection site and activates the solid immune response to nanoparticles [15]. Antigen-presenting cells (APC) absorb and present the spiked nanoparticles on their membrane to T lymphocytes via the major histocompatibility complex (MHC). T lymphocytes activate antibody-producing B cells. A different type can be initiated by an APC, called a killer T cell, which can recognize and destroy cells infected with the coronavirus before more new viruses spread [16].

Immunization from Oxford and AstraZeneca against COVID-19, it was shown to be 70% effective among those without any antibodies. Vaccine against modern disease Reports indicate that (mRNA-1273) is 94% effective against verified COVID-19, but the reality is that the initial vaccination wasn't enough to stave against the virus [17]. A study showed that the severity of COVID19 was associated with lymphopenia, monocytosis, and elevated NLR and PLR values. On the other hand, both values (NLR and PLR) could be used as hematological predictors for disease severity and the outcome of patients with COVID-19 [4]. While another study revealed that severe and critically ill patients had significantly lower lymphocyte count ($p<0.0001$), decreased red blood cell and hemoglobin ($p<0.01$), low levels of immunoglobulin G ($p<0.01$), fbrinogen ($p<0.0001$), and white blood cell count ($p<0.01$) [18]. Another study showed that total white blood cell counts was significantly increased in moderate and severe cases ($p=0.000$) compared to mild cases. Furthermore, neutrophil percentages were significantly increased ($p=0.000$), whereas lymphocyte percentages were decreased ($p=0.001$) in moderate and severe patients in comparison to mild patients [19].

The most common laboratory finding in COVID-19 is lymphopenia, COVID-19 patients presented with coagulopathy is at high risk of morbidity and mortality. In severe COVID-19 patients, bone marrow aspirate shows histiocytic proliferation with hemophagocytosis [20]. Leukocytosis (mainly granulocytosis and monocytosis) and

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lymphopenia, were the predominant abnormal findings of complete blood cell count (CBC) analysis of the patient's blood. Most of the patients had abnormally low platelet counts. RBC count and hematocrit determination were the only significant predictors of death. The clinician could manage cases according to the hematological findings of the patients [21].

Normal white blood cell and neutrophil count among COVID-19 patients was seen. However, median values in Group II ($P < 0.01$) and Group III ($P < 0.0001$) were found to show significantly higher values when compared to Group I. A significant ($P < 0.01$) decrease in lymphocytic counts was found among severe and critical patients. Hemoglobin level was found to demonstrate higher decrease ($P < 0.01$) among severe and critical patients. Platelet count was found in normal range in all COVID-19 patients. Routine coagulation tests revealed increased fibrinogen ($P < 0.01$) and d-dimer levels ($P < 0.0001$) in severe and critical patients. Normal proportions of total CD3+ and CD4 + T lymphocytes were observed in COVID-19. However, CD8 + T lymphocytes proportion was found to be decreased (P-value < 0.05). Immunoglobulin G levels among Groups II and III patients were found to be lower when compared with Group I ($P < 0.001$) [22]

The presence of IgA and IgG SARS-CoV-2 antibodies in 75 consecutive patients with confirmed COVID-19 infection was investi- gated. No significant differences were found between the IgA positive and negative groups, regarding the presence of symptoms, haematological and inflammatory variables, or the presence of pneumonia. In the majority of cases, antibody detection was comparable, for example, 79.7% of patients in the IgA positive group exhibited both types of antibodies, while 80.9% of patients in the IgA negative group were also IgG negative. A total of four patients in the IgA negative group presented with anti-SARS-CoV-2 IgG antibodies. Early detection of IgA was more frequent in patients who later developed severe forms of the disease. In addition, the IgG SARS-CoV-2 antibody response was higher in patients with the severe form of the disease [23]. Hematological parameters directly reflect the damage of SARS-CoV-2 to human blood cells, which can better assess the severity and prognosis of patients infected with COVID-19, but hematological parameters have some differences between adults and children. This article comprehensively reviews the differences in hematological parameters between adults and children after SARS-

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CoV-2 infection, and provides a reference for the diagnosis and treatment of COVID-19 [24].

RBC Increase in patients with P=0.0395, a slight decrease in WBC, decrease in LYM% with P=0.0107, Increasing in GRAN% with P=0.0354 was found, while a decrease in PIT with 0.0001>P, mid% with P=0.0047, HCT with 0.0001> P and MCV with P=0.0016, a slight decrease in MCH, MPV, and PCT with P=0.0035 [25]. Vitamin D and anti-SARS-CoV-2 IgG share common parameters associated with infammatory state. However, even though Vitamin D protects against severe forms of COVID-19 it could not directly afect anti-SARS-CoV-2 IgG production [26]. Dynamic changes in vital hematological parameters from severe and non-severe patients had been characterized in the course of hospitalization. During hospitalization, NLR was found to have certain relevance to the hospitalization days and a role in forecasting disease prognosis for patients with COVID-19 [27].

Conclusions:

The study found that vaccination is associated with a reduction in SARS-CoV-2 confirmed cases (confirmed by polymerase chain reaction, or PCR) and a less severe course of symptoms. Both the Pfizer and Sinopharm vaccines elicited detectable humoral immune responses (IgG > IgM). Due to the study's design limitations, these findings should be interpreted as correlations, not causal evidence. Future studies should include neutralizing antibody assays, assessment of T-cell immunity, and multicenter recruitment of participants.

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