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A Retrospective Study of COVID-19 Vaccine Reactogenicity and Reinfection Susceptibility by ABO Blood Group in a Libyan Academic Community

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Abstract:
Several reports have suggested that ABO blood groups and different COVID-19 vaccine platforms may influence susceptibility to infection and the pattern of post-vaccination reactions. In this study, we examined these factors in an academic community in Northwestern Libya. A total of 418 participants completed an online survey conducted between June and October 2022. Among them, 213 individuals (50.9%) reported previous COVID-19 infection, with the following blood group distribution among the infected: A (39%), O (38%), B (15.5%), and AB (7.5%). When blood group O was compared with all non-O groups combined (A, B and AB), individuals with group O showed a lower likelihood of reinfection (OR = 0.48, 95% CI: 0.24–0.96, p = 0.036). Additionally, most respondents (76.1%) had received at least one vaccine dose, and the pattern of reported side effects differed by vaccine type ($p < 0.0001$). Statistically, viral-vector vaccines (Sputnik V and AstraZeneca) were more frequently associated with systemic symptoms such as fatigue, headache, and fever. In contrast, recipients of the inactivated Sinopharm vaccine reported fewer reactions. These findings provide locally relevant information for the Libyan population and suggest that blood group O may be associated with a reduced risk of reinfection, and that the vaccine platform appears to influence short-term side-effect profiles experienced by the subjects.

Keywords: COVID-19, SARS-CoV-2, Prevalence, Blood Groups, COVID-19 Vaccine, Risk of Reinfection.

دراسة استرجاعية حول الاستجابة المناعية (التفاعلية) للقاح كوفيد-19 وقابلية الإصابة مرة أخرى بالعدوى حسب فصيلة الدم (ABO) لدى المجتمع الأكاديمي الليبي

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الملخص
أشارت تقارير عدة إلى أن فصائل الدم (ABO) والتقنيات المختلفة للقاحات كوفيد-19 قد تؤثر على قابلية الإصابة بالعدوى ونمط التفاعلات الناتجة بعد التطعيم. في هذه الدراسة، قمنا بفحص هذه العوامل لدى مجتمع أكاديمي في شمال غرب ليبيا. شارك ما مجموعه 418 مشاركاً في استبيان عبر الإنترنت أُجري في الفترة ما بين يونيو وأكتوبر 2022. ومن بين هؤلاء، أفاد 213 فرداً (50.9%) بإصابتهم المسبقة بكوفيد-19، مع توزيع فصائل الدم التالي بين المصابين: A (39%)، O (38%)، B (15.5%)، و AB (7.5%).
وعند مقارنة فصيلة الدم O بجميع الفصائل الأخرى مجتمعة(A, B, AB) ، أظهر الأفراد من الفصيلة O انخفاضاً في احتمالية الإصابة مرة أخرى بالعدوى. (OR = 0.48, 95\% CI: 0.24-0.96, p = 0.036) بالإضافة إلى ذلك، تلقى

غالبية المستجيبين (76.1%) جرعة واحدة على الأقل من اللقاح، واختلف نمط الآثار الجانبية المبلغ عنها باختلاف نوع اللقاح .($p < 0.0001$) كانت لقاحات الناقلات الفيروسية (سبوتنيك V وأسترازينيكا) مرتبطة بشكل متكرر بأعراض جهازية مثل التعب والصداع والحمى، بينما أبلغ متلقو لقاح سينوفارم (اللقاح غير النشط) عن تفاعلات أقل.
توفر هذه النتائج معلومات ذات صلة محلياً بدولة ليبيا، وتشير إلى أن فصيلة الدم O قد تكون مرتبطة بانخفاض خطر الإصابة مرة أخرى بالعدوى، كما يبدو أن نوع منصة اللقاح يؤثر على ملف الآثار الجانبية قصيرة المدى.

الكلمات المفتاحية: كوفيد-19، سارس-كوف-2، الانتشار، فصائل الدم، لقاح كوفيد-19، خطر الإصابة مرة أخرى بالعدوى.

Introduction

Background

In December 2019, the Chinese Centre for Disease Control and Prevention dispatched a rapid response team to conduct an epidemiological and etiological investigation in association with Hubei province and Wuhan city health authorities, as several local health facilities had reported clusters of patients with pneumonia of unknown cause [1,2]. It was identified as the severe respiratory syndrome coronavirus-2 (SARS-COV-2) [1], and was declared a pandemic by the World Health Organization WHO in February 2020. Libya, located in North Africa, was no exception, as the virus rapidly proliferated across the country, including the western regions. In March 2020, the first officially confirmed case of COVID-19 infection was reported in Libya, as a 73-year-old man returning from a trip to Saudi Arabia [3].

SARS-CoV-2 is a coronavirus type that belongs to the Coronaviridae family and has been found in several different species in addition to avian hosts. To effectively manage COVID-19 infection, early diagnosis, suitable therapy, and ongoing steps to stop the virus's transmission are necessary [4]. COVID-19 is from the same group of ribonucleic acid (RNA) viruses that caused severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). The name "coronaviruses" refers to enclosed, non-segmented, single-stranded, positive-sense RNA viruses that resemble coronas or crowns and are detected by electron microscopy. These projections are thought to be caused by massive surface spike proteins. Coronaviruses are classified in the Nidovirales order [5,6]. The SARS-CoV-2 virus relies on its obligate receptor, angiotensin-converting enzyme 2 (ACE2), to enter cells [7]. When the SARS-CoV-2 binds to the ACE2 receptor, the viral entity initiates the process of cellular infection, leading to the manifestation of various symptoms that are dependent upon the anatomical localization of the ACE2 receptor to which the virus adheres [8]. For instance, the occurrence of lung inflammation when SARS-CoV-2 interacts with the ACE2 receptor situated within the pulmonary system [9]. Likewise, the development of myocarditis is a potential consequence when SARS-CoV-2 binds with the ACE2 receptor found in the cardiac region [10]. Vaccination is central to defending against COVID-19 infection [11]. This led to a worldwide effort to develop an effective vaccine against SARS-CoV-2. A variety of vaccine forms have been developed to prevent the SARS-CoV-2 virus and subsequent COVID-19 disease, with different efficacies and adverse effects [12].

Significance of the Study

Host factors such as ABO blood groups and individual responses to different vaccine platforms have emerged as significant variables influencing COVID-19 susceptibility and outcomes [13,14]. However, findings across global populations remain inconsistent, and locally relevant data from Libya are limited. This study seeks to contribute local epidemiological insights from Northwestern Libya, where specific vaccine types and demographic factors may shape pandemic impact differently than in other regions.

Objective

The present study aimed to evaluate the frequency of COVID-19 infection and the vaccination status in an academic Libyan community in Northwestern Libya. Specifically, it examined the association between ABO blood groups and the risk of SARS-CoV-2 infection and reinfection, as well as the relationship between COVID-19 vaccine platforms and reported reactogenicity. Although COVID-19 is no longer categorized as a pandemic, research must continue to provide important local data on the impact of this pandemic on different populations.

Methods

Study Design and Data collection

A descriptive approach was employed in this research. Demographic and clinical data were collected using an online questionnaire prepared by the authors and distributed via Google Forms. The data included age, gender, blood group, BMI, history of chronic illness, COVID-19 infection and reinfection, history of hospitalization, vaccine type received, number of doses, and post-vaccine complications. Informed online consent was obtained from all participants. After excluding responses that were incomplete or internally inconsistent, 418 questionnaires were included in the final analysis. These were completed by university students, faculty members, and employees in Northwestern Libya between June and October 2022.

Statistical Analysis

Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as mean values with standard deviations. Comparisons of proportions were carried out using the chi-square test or Fisher's exact test when needed. A planned comparison was performed to examine reinfection risk by contrasting blood group O against the combined non-O groups, based on previous reports suggesting a potential biological difference. The relation between vaccine type and reported side effects was assessed in a similar manner. Statistical significance was defined as $p < 0.05$. All analyses were conducted using SPSS version 31.0 and figures generated using Prism GraphPad software.

Results

Demographic and Anthropometric Characteristics

A total of 418 respondents were included in the study. Their mean age was 30 ± 10.1 years (Table 1). Almost half were in the 21–30 years group (Figure 1). The majority were females, representing 77% (Figure 2). The mean body weight, height, and BMI were 67 ± 14.4 kg, 164 ± 9.9 cm, and 25 ± 8.0 kg/m², respectively (Table 1). Among these participants, 75.9% had received at least one dose of a COVID-19 vaccine. Their vaccination record was as follows: 33% received one injection, 56.3% received two injections, and 10.7% received three injections. We observed differences in the percentage of vaccination according to the number of doses in different age groups (Figure 3).

Table 1. Demographic, clinical characteristics, and COVID-19 Vaccination According to Age Groups in All Participants

		Total n= 418	<20 n = 52	21-30 n = 198	31-40 n = 106	41-50 n = 47	51-60 n = 13	61-70 n = 2
Age (year)		30 (10,10)	20 (0,46)	23 (2,30)	36 (2,68)	45 (3,12)	54 (2,95)	66 (0,71)
Sex (% female)		322 (77%)	39 (9%)	158 (38%)	87 (21%)	34 (8%)	4 (1%)	0 (0%)
Weight (kg)		67 (14,44)	62 (15,07)	63 (13,49)	72 (12,55)	75 (13,02)	81 (11,21)	80 (28,28)
Height (cm)		164 (9,94)	164 (8,26)	164 (11,53)	164 (7,56)	167 (9,04)	170 (8,42)	171 (8,49)
BMI (kg/m^2)		25 (7,97)	23,15 (5,19)	23,96 (10,43)	26,58 (4,16)	26,93 (4,03)	28,21 (2,85)	26,98 (6,99)
Vaccinated		318 (75,9%)	44 (10,5%)	153 (36,5%)	68 (16,2%)	39 (9,3%)	12 (2,9%)	2 (0,5%)
No. of doses	**One dose**	104 (33%)	14 (4%)	65 (20%)	15 (5%)	8 (3%)	2 (1%)	0 (0%)
	Two doses	179 (56,3%)	26 (8,2%)	80 (25,2%)	43 (13,5%)	21 (6,6%)	8 (2,6%)	1 (0,3%)
	Three doses	34 (10,7%)	4 (1,3%)	7 (2,2%)	10 (3,1%)	10 (3,1%)	2 (0,6%)	1 (0,3%)

A Chi-square test: Age groups and vaccination status, χ^2 (3, N = 418) = 16.01, $p < 0.001$

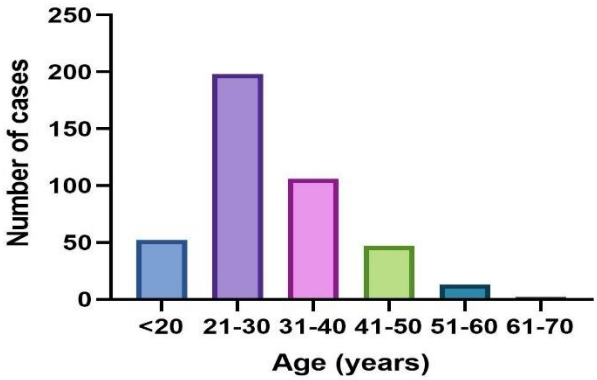

Figure 1. The distribution of participants in different age groups

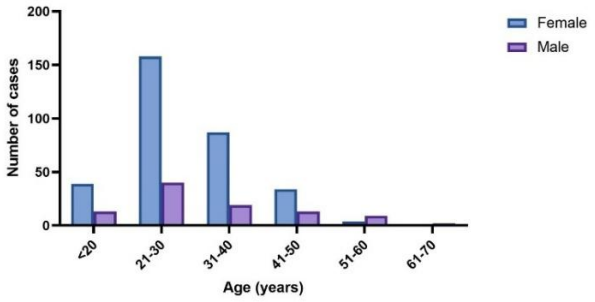

Figure 2. The distribution of gender in different age groups

The youngest participants were represented in all dose categories but were relatively more likely to have received two doses. The 21–30 age group was more common in the two-dose group than in the other groups. The 31–50 age group was relatively more likely to have received three doses, and they accounted for a greater proportion of *booster doses* compared with the younger and older age groups (Table 1, Figure 3). A chi-square test confirmed that the distribution of vaccine doses differed significantly by age category ($p < 0.001$). This result shows that vaccination uptake patterns varied across age groups.

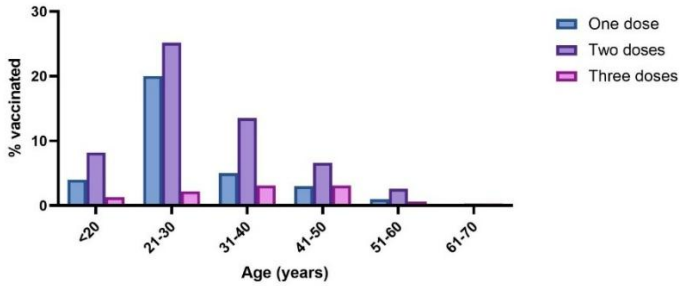

Figure 3. Percentage of vaccinated subjects according to the number of doses in different age groups

Vaccine Type Distribution

Regarding the percentage of each vaccine type, we detected Oxford/AstraZeneca as the most administered at 31%, followed by Sputnik V (26%), Sinopharm (22%), and Pfizer-BioNTech (16%) (Table 2, Figure 4). Indeed, vaccine doses for the 21–30 age group represented 47% (n=152) of all doses, reflecting the younger age structure of the study population (Table 2). As we expected, no statistically significant differences in vaccine type distribution were observed across age groups for either the first or second dose ($p = 0.151$, 0.541, respectively). Although our data on the booster dose was limited, we observed no age-related pattern.

Table 2. Type of COVID-19 vaccine according to dose and age groups

		Total n = 317	<20 n =44	21-30 n =152	31-40 n =68	41-50 n =39	51-60 n =12	61-70 n =2
First dose n = 104	Oxford/Astrazeneca	98	11	53	17	14	2	1
	Pfizer-BioNTech	52	8	20	17	6	1	0
	Moderna	8	2	4	0	0	2	0
	Johnson & Johnson	5	1	3	1	0	0	0
	Sinopharm	70	11	37	14	7	0	1
	Sputnik V	82	10	35	19	12	6	0
Second dose n = 179	Oxford/Astrazeneca	86	11	40	15	14	5	1
	Pfizer-BioNTech	52	6	18	19	7	2	0
	Moderna	3	2	1	0	0	0	0
	Johnson & Johnson	3	1	2	0	0	0	0
	Sinopharm	51	7	23	12	8	0	1
	Sputnik V	20	2	6	8	3	1	0
Third dose n = 34	Oxford/Astrazeneca	14	3	5	3	2	1	0
	Pfizer-BioNTech	22	2	3	9	7	1	0
	Moderna	1	0	1	0	0	0	0
	Johnson & Johnson	0	0	0	0	0	0	0
	Sinopharm	11	2	3	3	3	0	0
	Sputnik V	1	0	1	0	0	0	0

A Chi-square test: Age groups and vaccine type, χ^2 (16) = 20.19, p = 0.21.

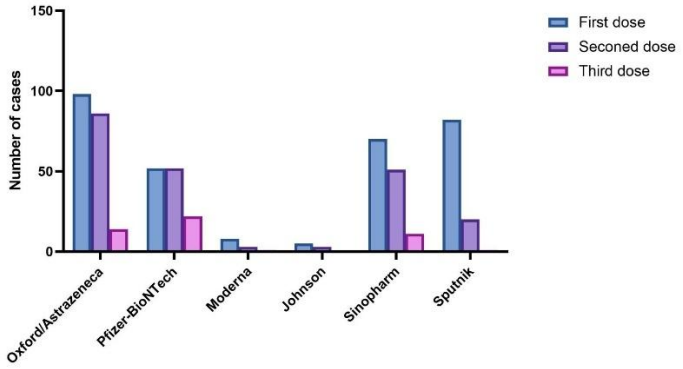

Figure 4. Distribution of participants according to type of vaccine and dose

Distribution of Symptoms According to Type of Vaccine

Of the 318 vaccinated participants, 53.4% (n = 170) reported at least one symptom. In general, we found that Sputnik V (71.9%, n = 59/82) had the highest percentage of symptoms, followed by Pfizer and AstraZeneca (59.6%, n = 31/52) and (56.1%, n = 55/98), respectively. In contrast, the Sinopharm group (24.6%, n = 17/69) was the lowest. Therefore, we excluded Moderna (62.5%, n = 5/8) and Johnson & Johnson (60.0%, n = 3/5) from the statistical analysis due to very small sample sizes. Using the chi-square test, we found a significant association between vaccine type and the prevalence of any symptom (p < 0.0001) for the four primary vaccine groups (AstraZeneca, Pfizer, Sinopharm, and Sputnik V).

Table 3 demonstrates that the most common side effects were general fatigue and myalgia (45%, n = 142), headache (35%, n = 112), and fever (31%, n = 99), while other symptoms were less commonly presented. The distribution of each common symptom differed significantly across vaccine types: fatigue/myalgia (p < 0.0001), headache (p < 0.0001), and fever (p < 0.0001). Participants vaccinated with Sputnik V or AstraZeneca were significantly more likely to report these common symptoms, followed by Pfizer, whereas Sinopharm recipients reported significantly fewer symptoms (Figure 5). Regarding other reported symptoms, we found their occurrence was rare. However, convulsion was reported in 3.1% (n = 10) of participants, with the highest frequency in the AstraZeneca group (7.1%, n = 7/98); moreover, this difference was not statistically significant (p = 0.135). Vomiting was reported by 2.8% (n = 9), high blood sugar by 0.9% (n = 3), and high blood pressure by 0.9% (n = 3). Due to the very small number of these specific symptoms, differences between groups were not statistically significant (vomiting: p = 0.49; high blood sugar: p = 0.245; high blood pressure: p = 0.24). These findings are presented as descriptive data.

Table 3. Distribution of symptoms according to type of vaccine

	Total n = 318		Astrazeneca n = 98		Johnson & Johnson n = 5		Moderna n = 8		Pfizer n = 52		Sinopharm n = 69		Sputnik V n = 82		*p* value
Symptoms present	170	53 %	55	17 %	3	1 %	5	2 %	31	10 %	17	5 %	59	19 %	0.0001
Fever	99	31 %	37	12 %	2	1 %	4	1 %	21	7 %	6	2 %	29	9 %	0.0001
Headache	112	35 %	38	12 %	3	1 %	2	1 %	23	7 %	8	3 %	38	12 %	0.0001
General Fatigue and Myalgia	142	45 %	46	14 %	3	1 %	5	2 %	26	8 %	13	4 %	49	15 %	0.0001
Vomiting	9	3 %	5	2 %	0	0 %	0	0 %	2	1 %	0	0 %	2	1 %	0.49
High blood sugar	3	1 %	3	1 %	0	0 %	0	0 %	0	0 %	0	0 %	0	0 %	0.245
High blood pressure	3	1 %	3	1 %	0	0 %	0	0 %	0	0 %	0	0 %	0	0 %	0.24
Convulsions	10	3 %	7	2 %	0	0 %	0	0 %	1	0 %	2	1 %	0	0 %	0.135

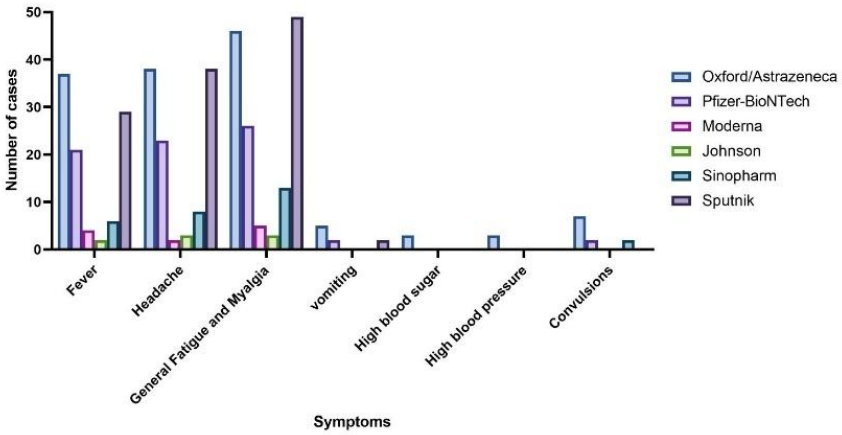

Figure 5. Symptoms according to the type of COVID-19 vaccine

Age and BMI-Related Patterns of Chronic Illness in COVID-19 Positive Participants

Half of the respondents (n = 213, 50%) had a positive COVID-19 test. The mean age ± SD was 31±9.85 years. Most 40%, where in the age group (21–30 years), followed by 30% (31–40 years), while only one participant was older than 60 years (Table 4, Figure 6). Moreover, female participants represented the majority of the study (77.5%, n = 165), with the highest proportion about 79% in the age group (21–30 years). Regarding their anthropometric measures, the mean ± SD BMI was lowest at 22.9 ± 5.5 kg/m² in the <20 years group and highest at 27.4 ± 3.7 kg/m² in the 51–60 years group. Table 4 also elucidates that chronic diseases were reported in 23 participants (10.8%). Endocrine and immune disorders (4.2%, n = 9) were the most common, followed by chronic pulmonary disease (2.8%, n = 6). Hypertension (0.9%, n = 2), diabetes mellitus (1.4%, n = 3), and chronic heart disease (0.5%, n = 1) were rare. Chronic diseases tended to be more frequent among participants aged 31–50 years. We kept the analysis descriptive, as the study population was predominantly young and female, with low rates of chronic disease. Although BMI increased with age, chronic conditions were slightly more frequent in middle-aged groups.

Table 4. Clinical characteristics of infected according to age groups

	Total n= 213	<20 n = 23	21-30 n = 85	31-40 n = 70	41-50 n = 31	51-60 n = 3	61-70 n = 1
Age (year)	31 (9,85)	20 (0,54)	23 (2,53)	36 (2,68)	45 (3,16)	56 (3,51)	66
Sex (% female)	165 (77,46%)	15 (7,04%)	67 (31,46%)	60 (28,17%)	23 (10,80%)	0 (0%)	0 (0%)
Weight (kg)	68 (14,15)	63 (17,54)	64 (13,82)	71 (12,60)	75 (11,06)	83 (15,87)	60
Height (cm)	165 (8,30)	166 (8,42)	164 (8,73)	164 (7,82)	167 (7,90)	174 (7,09)	165
BMI (kg/m2)	25,05 (4,44)	22,92 (5,48)	23,79 (4,01)	26,37 (4,25)	26,97 (3,65)	27,36 (3,72)	22,04
Chronic disease	23 (10,8%)	1 (0,5%)	2 (0,9%)	10 (4,7%)	10 (4,7%)	0 (0%)	0 (0%)
DM	3 (1,4%)	0 (0%)	0 (0%)	1 (0,5%)	2 (0,9%)	0 (0%)	0 (0%)
Hypertension	2 (0,9%)	0 (0%)	0 (0%)	1 (0,5%)	1 (0,5%)	0 (0%)	0 (0%)
Chronic pulmonary disease	6 (2,8%)	1 (0,5%)	1 (0,5%)	2 (0,9%)	2 (0,9%)	0 (0%)	0 (0%)
Chronic heart disease	1 (0,5%)	0 (0%)	0 (0%)	1 (0,5%)	0 (0%)	0 (0%)	0 (0%)
Endocrine and immune disease	9 (4,2%)	0 (0%)	1 (0,5%)	3 (1,4%)	5 (2,3%)	0 (0%)	0 (0%)
Others	2 (1%)	0 (0%)	0 (0%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)

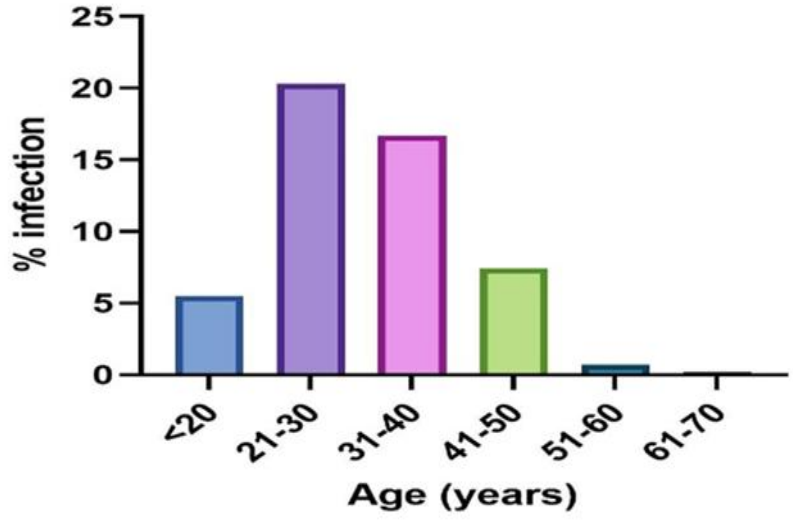

Figure 6. The distribution of infected in different age groups

Distribution of Infected According to Blood Group and Rhesus Factor

We investigated the association between ABO blood group and two distinct COVID-19 outcomes: initial infection susceptibility and reinfection risk. The distribution of infections among blood groups was as follows: participants with blood group A had 83 infections (59 single, 21 twice, 3 > twice); AB group had 16 infections (12 single, 4 twice, 1 > twice); B group had 33 infections (21 single, 12 twice, 1 > twice); and O group had 81 infections (67 single, 12 twice, 2 > twice) (Table 5).

Analysis of initial infection susceptibility across all four ABO blood groups revealed no significant association ($p = 0.342$). Given the biological hypothesis that anti-A and anti-B antibodies present in blood group O individuals may interfere with viral adhesion [13,14], and following methodological precedent [15]. We performed a pre-specified analysis focusing on reinfection risk. Comparison of blood group O against non-O groups (A, B, and AB combined) showed that individuals with blood group O had statistically significant lower susceptibility to reinfection ($p = 0.036$).

Regarding the Rhesus factor, among 189 Rh-positive participants, 142 were infected once, 44 twice, and 6 with multiple infections, while among 24 Rh-negative participants, 17 were infected once, 5 twice, and 2 more than twice. No significant association was observed between Rh factor and infection outcomes ($p = 0.654$).

Table 5. Distribution of infected according to blood group and rhesus factor

	Total		**A**		**AB**		**B**		**O**		***p* value**	**O**	**Non O**	***p* value**	**Rh +ve**		**Rh -ve**		***p* value**
Infected	213	100 %	83	39 %	16	8 %	33	15 %	81	38 %	0.342	81 38%	132 61%		189	89 %	24	11 %	0.654
Once	159	75 %	59	28 %	12	6 %	21	10 %	67	31 %		67 42%	92 57%	0.036	142	67 %	17	8 %	
Twice	49	23 %	21	10 %	4	2 %	12	6 %	12	6 %		14 27%	40 72%		44	21 %	5	2 %	
> 2 times	8	4 %	3	1 %	1	0 %	1	0 %	2	1 %					6	3 %	2	0 %	

Clinical Characteristics and Number of COVID-19 Infections According to Hospitalization Days

The statistical analysis of Table 6 revealed that there was no statistically significant correlation between the hospitalization stay and ABO blood group, Rhesus factor, and infection frequency. Besides that, the distribution of hospitalization days was similar across ABO blood groups and Rhesus factor ($p = 0.693$ and 0.569, respectively). Despite the different numbers of infections, we did not observe a statistically significant relation to hospitalization duration ($p = 0.624$). However, these findings indicate that genetic blood group factors and reinfection frequency did not influence the length of hospitalization in this study population.

Table 6. Clinical characteristics and number of times of COVID-19 infection according to hospitalization days.

	Total n = 25	< 10 days n = 8	10 – 15 days n = 12	> 15 days n = 5	*p* value
Age	30.52 (10.5)	32 (10.2)	28 (11.5)	34 (9.7)	-
Sex (% female)	19 (76%)	5 (26.3%)	10 (52.6%)	4 (21.1%)	-
BMI (kg/m^2)	24.92 (4.3)	26.79 (5.4)	23.96 (3.3)	24.24 (4.4)	-
ABO blood group					0.482
A	11 (44%)	3 (27.3%)	5 (45.4%)	3 (27.3%)	-
B	4 (16%)	1 (25%)	2 (50%)	1 (25%)	-
AB	2 (8%)	0 (0)	2 (100%)	0 (0)	-
O	8 (32%)	4 (50%)	3 (37.5%)	1 (12.5%)	-
Rh blood group					1.000
Rh +ve	24 (96%)	8 (33.3%)	11 (45.8%)	5 (20.8%)	-
Rh -ve	1 (4%)	0 (0)	1 (100%)	0 (0)	-
Chronic disease	6 (24%)	1 (16.7%)	1 (16.7%)	4 (66.7%)	0.22
Infection (n)					0.42
Infected once	18 (72%)	7 (38.9%)	7 (38.9%)	4 (22.2%)	-
Infected twice	6 (24%)	1 (16.7%)	4 (66.7%)	1 (16.7%)	-
Infected > 2 times	1 (4%)	0 (0)	1 (100%)	0 (0)	-

Discussion

This study examined patterns of COVID-19 infection and vaccination among members of a university community in Northwestern Libya and explored how these factors appeared to relate to one another. Some of the observations we made resemble what has been reported in studies from other countries, although not all patterns were identical. The results add locally generated information that helps clarify how the pandemic affected this particular Libyan community. We discuss our results, highlighting the points of convergence and divergence with previous international studies.

According to the National Centre for Disease Control, Libya NCDC-Libya [16], the total number of individuals vaccinated against COVID-19 by 15th of Jan 2023, has reached 3,739,158, and of those vaccinated, 195,990 have received three doses, while 1,242,316 have received two doses only, and 1,081,614 have received a single dose only. There is no clear data on the distribution of the different COVID-19 vaccine types in Libya. This may reflect a complex interplay of regional access and vaccine availability.

Our data revealed a statistically significant association between age and the number of vaccine doses received ($p = 0.001$), while the type of vaccine was not age-related. The high proportion of vaccinated participants in the 21–30-year age group reflects the majority of this age group in our study population. However, the observed higher uptake of booster doses was within the 31–50-year age group, which is consistent with international health strategies giving priorities to older and higher-risk adults to reduce severe morbidity and mortality. The overall vaccination rate of 75.9% was satisfactory despite variation in the completion of the full required doses.

The most common vaccines administered among this population were Oxford/AstraZeneca (31%), Sputnik V (26%), and Sinopharm (22%), with no significant link between vaccine type and participant age. This distribution reflects the region's available supply during the pandemic, as the Sputnik V and Sinopharm were the primary administered vaccines in Libya with regional variation [17]. This result clearly indicates that the administration of vaccines was based on the region's supply, not on international health policies. For the next vaccine campaign, our findings highlight the importance of considering international guidelines to achieve better health outcomes and avoid complications in high-risk groups.

One of the notable observations was that the type of vaccine appeared to influence the short-term reactions reported by participants. As expected, over half of the vaccinated participants reported at least one symptom, as anticipated after vaccination. Our local data finding contributes to a better understanding of the internationally published results. For instance, fatigue, myalgia, headache, and fever were the most common symptoms in our study. Our results are consistent with and thereby reinforce international findings regarding common post-vaccination symptoms [18,19,20]. However, this rate varied obviously and statistically between vaccines. We found that Sputnik V and AstraZeneca vaccines were associated with the highest rates of common vaccine-induced side effects, including fatigue, muscle pain, headache, and fever ($p < 0.0001$). This pattern is not unexpected because viral-vector vaccines generally provoke a more pronounced inflammatory response [21,22]. In contrast, recipients of the Sinopharm vaccine, which uses an inactivated virus approach, reported significantly fewer systemic symptoms ($p < 0.0001$), a finding consistent with previously published results [23,24]. Moreover, the Pfizer vaccine, which uses mRNA technology, was associated with side effects of intermediate severity, being less severe than those associated with viral vector vaccines ($p < 0.0001$) [25,26]. Overall, the data suggest that

differences in vaccine technology likely played a role in the frequency of reported side effects.
A few participants mentioned symptoms such as convulsions or changes in blood sugar, but these occurred infrequently and did not show a clear pattern across vaccine types; this finding is consistent with data reported by others [27]. Although our sample was not large but our results still provide important context. For an accurate conclusion, these symptoms should be monitored in a larger population. These findings point to noticeable differences in reactogenicity between the vaccines that were administered [28]. The Sinopharm vaccine is still effective and induces milder side effects. Future research should continue to monitor for rare side effects in the larger Libyan population.
Many studies have linked higher BMI with more severe forms of COVID-19, and this has been well documented in various settings. Excess weight is associated with significantly increased risks of severe COVID-19 outcomes, and is a significant risk factor for intensive care unit (ICU) admission, particularly for invasive mechanical ventilation (IMV) requirement in COVID-19 [29,30,31]. Obesity is significantly associated with increased mortality among COVID-19 patients. One explanation often proposed is that obesity is associated with changes in immune function that may reduce the ability to respond quickly to infection [32,33]. However, in our study, the mean BMI for all participants was 25 kg/m² (within the normal range), and the mean BMI for infected participants was 25.05 kg/m². The population was predominantly young and healthy females, with a low rate of chronic illnesses (10.8%) and rare significant comorbidities such as hypertension and diabetes. The relatively young age of most participants, along with the generally normal BMI values, may account for the limited number of severe cases and the absence of a clear BMI-related trend in our sample.
Research on ABO blood groups and COVID-19 has produced divergent results. Studies associate group A with a higher risk of hospitalization and infection [13,34], while group O has been linked to better outcomes, a lower risk of respiratory failure [13,35,36], and a lower overall infection rate compared to non-O groups [14]. This protective role for group O, which may be attributable to the presence of anti-A and anti-B antibodies in these individuals, is supported by large-scale analyses [37] and aligns with a hypothesized antibody-mediated mechanism. In our data, while neither ABO group nor Rh factor influenced initial infection severity, blood group O was significantly associated with a lower risk of reinfection compared to non-O groups (OR = 0.48, 95% CI: 0.24–0.96, p = 0.036), accounting for 82.7% of single-infection cases. This finding is consistent with other international reports on reinfection [37,38]. In contrast, infection recurrence among types A, B, and AB was nonsignificant. The distribution of Rh factors in our study reflected general population statistics [39,40], but did not predict infection risk or severity. Further research with larger, more diverse samples is needed to clarify the factors shaping COVID-19 risk and clinical course.
Our study has several limitations. The reliance on self-reported data for infection history, vaccination status, and side effects may introduce recall or reporting bias. The use of convenience sampling within an academic community may limit generalizability to the broader Libyan population. Additionally, the analytical approach was primarily descriptive; while significant statistical associations were identified, the study did not employ multivariate regression models to control for potential confounding variables such as age, gender, or comorbidities. Future research using more advanced analytical approaches could further clarify these patterns and their underlying determinants.

Conclusion

This study offers locally generated information on COVID-19 infection and vaccination patterns within an academic community in Northwestern Libya. The data indicate that individuals with blood group O were less likely to experience reinfection, while the other blood groups showed no meaningful differences in this regard. The analysis also suggests that vaccines based on viral-vector platforms tended to produce more short-term systemic reactions than the inactivated or mRNA vaccines used in the region. Although these observations are in line with many reports from outside Libya, they also reflect the distribution of vaccines actually available to the community during the study period. Because the sample consisted mainly of young adults with few chronic illnesses, severe disease was uncommon, and this should be kept in mind when interpreting the findings. Despite these limitations, the study provides data that can help inform local health planning and guide future investigations. Larger studies that include broader segments of the Libyan population would be valuable for confirming and expanding on these results.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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