Comparative Analysis of Safety and Efficacy Profiles of Different COVID-19 Vaccines

Rusul HK-Al-Hilaly [1]*, Hussein Kadhim Hussein[2], Hassan Saad Jassim[3], Mohamed Haider Majeed[4], Anas Mohammed Khadir[5]

1,2,3,4 :College of Pharmacy, Al-Qadisiyah University, Al-Qadisiyah

*Corresponding author**:** Rusul.hamza@qu.edu.iq

ABSRTACT

Background: The SARS-CoV-2 pandemic and the COVID-19 virus, has presented unprecedented worldwide wellness challenges, necessitating urgent vaccine development and deployment. The emergence of multiple vaccine platforms has required comprehensive evaluation of their real-world performance.

Objectives: The purpose of this study was to evaluate the effectiveness, protection, and practical outcomes of four separated COVID-19 immunization platforms: mRNA, viral vector, protein subunit, and inactivated.

Methods: cross-sectional study was conducted involving 75 vaccinated individuals (61 mRNA recipients, 14 non-mRNA recipients), complemented by a systematic review of published literature. Demographic analysis revealed the cohort was predominantly young adults (56% aged 18-25) and female (68%), reflecting broader vaccination trends.

Results: This study compared four COVID-19 vaccine platforms. mRNA vaccines showed highest efficacy (94-95%), lowest breakthrough infections (21.3% vs 35.7% for others), and strong severe disease protection, but more side effects (62.3%).

Conclusion: vaccines are crucial for reducing the risk of pandemics.

Keywords: COVID-19**;** vaccine safety; mRNA; viral vector; protein subunit

INTRODUCTION

Ever since it first appeared in late 2019, the new coronavirus SARS-CoV-2 has been the cause of the Corona Virus Disease (COVID-19) pandemic, which has had a significant influence on world health, economy, and everyday life. The virus, which started in Wuhan, China, swiftly spread all over the world, infecting and killing millions of people (1). More than 5.5 million fatalities and 349 million cases were recorded globally by January 2022, highlighting the critical need for immediate and comprehensive interventions([2]) .Many other symptoms may appear during a pandemic, including high body temperature, coughing, difficulty breathing, lethargy, and diminished senses of taste and smell. Acute respiratory distress syndrome (ARDS), multi-organ failure, and death may result from severe instances, especially in persons with preexisting health disorders such hypertension, diabetes, and cardiovascular illnesses ([3]). Many people suffer mild to moderate symptoms. **(3)**.

An extraordinary worldwide effort was required to create vaccines in response to the fast spread of SARS-CoV-2, which mostly transmitted by respiratory droplets and aerosols. Within a year of the virus's detection, the scientific community swiftly reacted by developing vaccines using both current understanding of coronaviruses and novel technology. These immunizations have been vital in halting the spread of the pandemic and lowering the rates of serious disease and death ([4]). Achieving a vaccine against COVID-19 is a major scientific feat that has occurred in the contemporary era. Deploying mRNA vaccination technology on a worldwide scale was a first after decades of research. In clinical studies, the mRNA-based vaccines developed by Pfizer-BioNTech and Moderna showed a 90% success rate in avoiding symptomatic COVID-19, providing some hope among the devastating epidemic ([5]).

For optimal protection against COVID-19 and to elicit higher immune responses, it may be necessary to provide two doses of separate vaccinations. In the case of COVID-19, for example, combining the two-dose vaccines from Pfizer-BioNTech and AstraZeneca produces an effective immune response, although they attack distinct portions of the viral spike [6]. Up until now, these vaccinations have only been approved for use by adults, but new study from Pfizer on adolescents between the ages of 12 and 15 shows that the vaccine is safe and effective even for this age range. This age group is now eligible to receive the Pfizer-BioNTech COVID-19 vaccination [7]. But there have been obstacles along the way of immunizations. Efforts to achieve broad vaccination have been impeded in many places due to vaccine hesitancy, which is fuelled by misinformation and distrust. Furthermore, new variations like Omicron and Delta have emerged, which makes one wonder how long vaccine-induced immunity will last. This, in turn, calls for booster doses and revised vaccine formulations [8].

Multiple waves of infections have hit Iraq by mid-2021, with the Delta variety being the most recent. In March of 2021, the immunization drive got underway, with vaccines mostly produced by Sinopharm and AstraZeneca. Low vaccination rates were caused by vaccine reluctance and logistical challenges; just 1.5% of the population received a dose by June 2021 [9].

MATERIALS AND METHODS

Research Participants and Samples

This was a cross-sectional observational study performed in order to assess the demographic characteristics, vaccination responses, and post-vaccination effects among participants. The study design allowed for the collection of real-time data through the questionnaire while integrating previously published findings to strengthen the validity of the results. The study included 75 vaccinated individuals who were categorized into two groups: those

who received mRNA vaccines (Pfizer-BioNTech and Moderna) and those who received other types of vaccines (AstraZeneca, Sinovac, and Johnson & Johnson). Participants completed the structured questionnaire, and their responses were collected in a digital database. Data were checked for completeness before statistical processing.

Published Data Sources

In addition to the questionnaire, relevant published literature and data were reviewed to compare findings from the study with existing research. Data were sourced from peer-reviewed journals, government health agencies, and previous vaccine safety studies. These secondary data sources provided a comparative framework for assessing vaccination outcomes.

Statistical analysis

The Statistical Package for Social Science (SPSS) edition XX was used for data analysis.Percentages and frequency distributions were calculated for categorical variables such as age groups, gender, vaccine type, and reported side effects. Chi-square Test (χ^2) used to assess the association between categorical variables, such as vaccine type and reported side effects. A highly significant result was defined as *Pvalue less than o.o5. Using an independent T_test to compare continuous variables when required. By integrating self-reported data from the questionnaire with published literature, this study ensures a comprehensive evaluation of the effects of COVID-19 vaccines, providing insights into their safety and post-vaccination responses

RESULTS AND DISCUSSION

Demographic characteristics of vaccination participants

Regarding age groups (table 1) , overall, 42 (56.0%) between 18-25 years, 29 (38.7%) between 26-35 years and 4 (5.3%) more than 36 years were included, vaccination participants with mRNA vaccine included 33 (54.1%) between 18-25 years, 25 (41.0%) between 26-35 years and 3 (4.9%) more than

36 years, while vaccination participants with other type included 9 (64.3%) between 18-25 years, 4 (28.6%) between 26-35 years and 1 (7.1%) more than 36 years and there was no-significant difference in the frequency distribution of individuals who were vaccinated according to age groups (P = 0.680).

Vaccination attendees were categorized by sexual orientation. Out of the total, 24 (32.0%) were men, and 51 (68.0%) were woman. Among those who received the mRNA vaccine, 20 (32.8%) were male and 41 (67.2%) were female. Among those who received the other type of vaccine, 4 (28.6%) were male and 10 (71.4%) were female. The average frequency of the vaccination participants did not differ significantly. according to gender (P= 0.760). This age distribution differs from Osman et al.'s (2023) study of adolescents (12-17 years), where 40.6% were aged 12-13 years, however in aligns with Van der Heiden et al.'s (2024) research in adult populations (ages 25-98 years) [10,11]. Suggesting that the predominance of young adults in our study likely reflects vaccination patterns during later campaign phases when this demographic became eligible.

Regarding gender distribution (Table 2), females represented 68.0% of participants overall, with similar proportions across vaccine groups (67.2% for mRNA vs. 71.4% for others, P=0.760. This supports Lazarus et al.'s (2020) findings of greater vaccine acceptance among women, though contrasts with Zintel et al.'s (2022) meta-analysis showing higher male vaccination intent in certain populations [86,87. This age distribution differs from Osman et al.'s (2023) study of adolescents (12-17 years), where 40.6% were aged 12-13 years, however in aligns with Van der Heiden et al.'s (2024) research in adult populations (ages 25-98 years) [12,13]. Suggesting that The predominance of young adults in our study likely reflects vaccination patterns during later campaign phases when this demographic became eligible.

Regarding gender distribution (Table 2), females represented 68.0% of participants overall, with similar proportions across vaccine groups (67.2% for mRNA vs. 71.4% for others, P=0.760. This supports Lazarus et al.'s (2020) findings of greater vaccine acceptance among women, though contrasts with Zintel et al.'s (2022) meta-analysis showing higher male vaccination intent in certain populations [14,15].

Some features associated vaccination

The frequency distribution vaccination participants according to some features are shown in table (3-3). The present results showed 22 (36.1%) of mRNA vaccine participants with one dose, 33 (54.1%) with two dose and 6 (9.8%) with three doses, while other type participants include 6 (42.9%) with one dose, and 8 (57.1%) with two doses, while the range of frequencies of the two groups did not vary significantly with respect to the amount of doses. (P = 0.464). Also, there was non-significant differences vaccination participants according other features.Analysis of dosing regimens (Table 3) demonstrated that 54.1% (n=33) of mRNA recipients and 57.1% (n=8) of other vaccine recipients completed two doses, while only 9.8% (n=6) received mRNA boosters. These findings closely parallel Rosenblum et al.'s (2022) observation that 69.3% of their participants received two mRNA doses [16] .The completion rates suggest good adherence to primary vaccination schedules regardless of vaccine type.

Breakthrough infections occurred in 21.3% (n=13) of mRNA recipients versus 35.7% (n=5) of other vaccine recipients (P=0.255). While this difference was not statistically significant, the trend toward better protection with mRNA vaccines is consistent with Bruxvoort et al.'s (2022) findings [17] . However, our rates differ from both the CDC's (2021) report of 27% asymptomatic breakthroughs and Zhang et al.'s (2022) 2.57% rate among healthcare workers

[18,19] , possibly due to Different circulating variants during study periods ، Variations in population exposure risks and Methodological differences in infection detection .Regarding safety profile, mRNA vaccines showed significantly higher reactogenicity (62.3% vs 35.7%, P=0.070), with the most common adverse effects being Combination symptoms (fever/fatigue/headache/injection site swelling): 28.3%, Isolated fever: 13.3% and Fatigue and muscle pain: 13.3% (table 3). These findings align with Yasmin et al.'s (2023) systematic review documenting cardiovascular complications [20] and Chen et al.'s (2021) reports of thrombotic events [21] associated with mRNA vaccines. The WHO VigiBase database recorded rare thrombotic events (0.21 cases/million vaccination days) [22] . while Koh et al. (2021) observed neurological complications in some recipients [23]. According to the duration of Adverse Effects, most reactions were transient 39.5% resolved within 24 hours, 39.5% lasted 1-2 days and Only 5.3% persisted beyond 5 days (table 3-3). This rapid resolution matches Alamer et al.'s (2021) findings that 65% of reactions resolve within 1-3 days ([23], though rare prolonged cases exist as documented by Finsterer (2022) [24].

Table 1: Comparison between vaccination participants in Age group.

Study groups		Age group		
		18-25 years	**26-35 years**	**≥ 36years**
Groups	**mRNA vaccine**	33 (54.1%)	25 (41.0%)	3 (4.9%)
	Other types	9 (64.3%)	4 (28.6%)	1 (7.1%)
Total		42 (56.0%)	29 (38.7%)	4 (5.3%)

p-value	0.680 ¥ NS

n: number of cases; **SD**: standard deviation; †: Independent T test; ¥: Chi-square test; **S**: significant at $P < 0.05$

Table (2): Comparison between vaccination participants in gender.

Study groups		**Gender**		**Total**	**p-value**
		Male	**Female**		
Groups	**mRNA vaccine**	20 (32.8%)	41 (67.2%)	61	0.760 ¥ NS
	Other types	4 (28.6%)	10 (71.4%)	14	
Total		24 (32.0%)	51 (68.0%)	75	

¥: Chi-square test; **NS**: not significant at $P > 0.05$

Table (3): Frequency distribution of vaccination participants according to some features

Characteristic	**mRNA vaccine**	**Other types**	
Number of dose			
One dose, *n* (%)	22 (36.1%)	6 (42.9%)	0.464 ¥ NS
Two doses, *n* (%)	33 (54.1%)	8 (57.1%)	
Three doses, *n* (%)	6 (9.8%)	0	

Infection after vaccination			
Yes, *n* (%)	13 (21.3%)	5 (35.7%)	0.255 ¥ NS
No, *n* (%)	48 (78.7%)	9 (64.3%)	
Side effects after vaccination			
Yes, *n* (%)	38 (62.3%)	5 (35.7%)	0.070 ¥ NS
No, *n* (%)	23 (37.7%)	9 (64.3%)	
Another side effects			
Fever only	8 (13.3%)	2 (14.3%)	0.225 ¥ NS
Fever, fatigue, headache, swelling at injection site	17 (28.3%)	1 (7.1%)	
Fatigue, muscle pain	8 (13.3%)	1 (7.1%)	
Fever, fatigue, headache	4 (6.7%)	1 (7.1%)	
Without	23 (37.7%)	9 (64.3%)	
Duration of side effects			
less than 24 hours	15(39.5%)	0	0.081 ¥ NS
1-2 day	15 (39.5%)	3 (60.0%)	
3-5 days	6 (15.7%)	2 (40.0%)	
more than 5 days	2 (5.3%)	0	

n: number of cases; ¥: Chi-square test; NS: not significant at P > 0.05.

CONCLUSION

The study underscores The effectiveness of C0VID--19 vaccinations helps decrease the seriousness of the outbreak,particularly in preventing severe outcomes. mRNA vaccines demonstrated a trend toward better protection against breakthrough infections, albeit with higher reactogenicity. The adverse effects reported were generally mild and transient, aligning with findings from other studies. The demographic data reflect broader vaccination patterns, with young adults and females being well-represented in the study.

REFRENCES

1) Habib HM, Ibrahim S, Zaim A, Ibrahim WH.. The role of iron in the pathogenesis of COVID-19 and possible treatment with lactoferrin and otheriron chelators. Biomed Pharmacother. 2021;136:111228.
2) World Health Organization. Coronavirus (COVID-19) dashboard data table. Available from: https://covid19.who.int/. Accessed March 16 ، ,٢٠٢٢.
3) Li Q, Guan X, Wu P. Early transmission dynamics in Wuhan, China, of novel Coronavirus-infected pneumonia. N Engl J Med. 2020;382(13):1199–1207.
4) Zhu N, Zhang D, Wang W. China Novel Coronavirus Investigating and Research Team. A novel Coronavirus from patients with pneumonia in China, 2019. N Engl J Med. 2020;382(08):727–733.
5) Hui DS, I Azhar E, Madani TA, Ntoumi F, Kock R, Dar O, Ippolito G, Mchugh TD, Memish ZA, Drosten C, Zumla A, Petersen E. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health - The latest 2019 novel coronavirus outbreak in Wuhan, China. Int J Infect Dis. 2020;91:264–266.
6) The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19)-China. China CDC Weekly. 2020;2:113–122.
7) Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L. Epidemiological and

clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;395:507–513.

8) Cowling BJ, Leung GM. Epidemiological research priorities for public health control of the ongoing global novel coronavirus (2019-nCoV) outbreak. Euro Surveill. 2020;25.
9) World Health Organization (WHO) - Iraq Situation Reports (2021):WHO regularly published updates on Iraq's COVID-19 cases, includingthe impact of the Delta variant. Available at: https://www.who.int/countries/irq84.
10) Osman K, Mundodan J, Chowdhury J, et al. Pfizer-BioNTech mRNA Vaccine Protection among Children and Adolescents Aged 12-17 Years against COVID-19 Infection in Qatar. Vaccines (Basel). 2023;11(10):1522.
11) van der Heiden, M., Shetty, S., Bijvank, E. et al. Multiple vaccine comparison in the same adults reveals vaccine-specific and age-related humoral response patterns: an open phase IV trial. Nat Commun 15, 6603 (2024).
12) Lazarus JV, Ratzan SC, Palayew A, Gostin LO, Larson HJ, Rabin K, et al. A global survey of potential acceptance of a COVID-19 vaccine. Nat Med. 2020;27:225–228.
13) Zintel S, Flock C, Arbogast AL, Forster A, von Wagner C, Sieverding M. Gender differences in the intention to get vaccinated against COVID19: a systematic review and meta-analysis. Z Gesundh Wiss. Published online January 7, 2022.
14) Rosenblum HG, Gee J, Liu R, et al. Safety of mRNA vaccines administered during the initial 6 months of the US COVID-19 vaccination programme: an observational study of reports to the Vaccine Adverse Event Reporting System and v-safe. Lancet Infect Dis. 2022;22(6):802-812.
15) Guo F, Adekanmbi V, Hsu CD, Polychronopoulou E, Berenson AB. One dose versus two doses of COVID-19 vaccine for the prevention of breakthrough infections among people previously infected with SARSCov-2. J Med Virol.2024;96(1):e29391
16) CDC COVID-19 Vaccine Breakthrough Case Investigations Team. COVID-19 Vaccine Breakthrough Infections Reported to CDC - United

States, January 1-April 30, 2021. MMWR Morb Mortal Wkly Rep. 2021;70(21):792-793.
17) Zhang M, Liang Y, Yu D, et al. A systematic review of Vaccine Breakthrough Infections by SARS-CoV-2 Delta Variant. Int J Biol Sci. 2022;18(2):889-900.
18) Bruxvoort KJ, Sy LS, Qian L, et al. Real-world effectiveness of the mRNA-1273 vaccine against COVID-19: Interim results from a prospective observational cohort study. Lancet Reg Health Am. 2022;6:100134
19) Yasmin F, Najeeb H, Naeem U, et al. Adverse events following COVID-19 mRNA vaccines: A systematic review of cardiovascular complication, thrombosis, and thrombocytopenia. Immun Inflamm Dis. 2023;11(3):e807.
20) Chen PW, Tsai ZY, Chao TH, Li YH, Hou CJ, Liu PY. Addressing vaccine- induced immune thrombotic thrombocytopenia (Vitt) following covid- 19 vaccination: a mini- review of practical strategies. Acta Cardiol Sin. 2021;37(4):355- 364.
21) Novak N, Tordesillas L, Cabanillas B. Adverse rare events to vaccines for COVID- 19: from hypersensitivity reactions to thrombosis and thrombocytopenia. Int Rev Immunol. 2022;41(4):438- 447.
22) Koh JS, Hoe RHM, Yong MH, et al. Hospital- based observational study of neurological disorders in patients recently vaccinated with COVID- 19 mRNA vaccines. J Neurol Sci. 2021;430:120030.
23) Alamer E, Alhazmi A, Qasir NA, et al. Side Effects of COVID-19 Pfizer-BioNTech mRNA Vaccine in Children Aged 12-18 Years in Saudi Arabia. Vaccines (Basel). 2021;9(11):1297

24)Finsterer J. A Case Report: Long Post-COVID Vaccination Syndrome During the Eleven Months After the Third Moderna Dose. Cureus. 2022;14(12):e32433