

## COMPARISON OF POST-VACCINATION COMPLICATIONS BETWEEN FIRST AND SECOND DOSE OF COVID-19 VACCINES AMONG PEOPLE NEAR THE VICINITY OF JINNAH POSTGRADUATE MEDICAL CENTRE, KARACHI

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### ABSTRACT

This cross-sectional study aimed to evaluate the post-vaccination complications of vaccines on the people around the setting of JPMC, Karachi, in Pakistan, and compare the complications of the first and second doses of COVID-19 vaccines, conducted from May 2021 to June 2022. Only vaccinated people participated in the study. We collected the data through questionnaires and by interacting with the participants. Data was analyzed through SPSS version 21 with a 95% confidence interval and significance level ( $p < 0.05$ ). The total number of participants was 325, aged between 20 to 70. About 55.7% of the participants were female, while 44% were male. 28% of the participants got positive COVID tests in the past. 48.9% were medical students, 19.1% were doctors, 2.5% were pharmacists, 0.3% were nurses, and 29.2% were of other professions. About 40.3% of the participants got Sinopharm, 33% got Sinovac, 5% got Moderna, 16% got Pfizer, 4.3% got AstraZeneca, and 1.5% got Sputnik V. About 57.9% experienced minor complications after the first dose of the vaccine, and 48.3% experienced minor complications after the second dose. Among these complications, headache, fatigue, and muscle ache were statistically significant, with p-values of 0.020, 0.000, and 0.042, respectively. The study inferred that no significant health complications were reported in participants after both doses of COVID-19 vaccination, and there is a low risk of adverse effects after COVID-19 vaccination.

**Key-words:** Vaccination, COVID-19, doses, complications of vaccines, COVID tests, Pakistan, Karachi

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### INTRODUCTION

In December 2019, many cases of pneumonia of unknown cause were reported in Wuhan, Hubei, China, which led to the identification of a new virus named SARS-CoV-2 (Singhal, 2020). Later, it was named COVID-19. This virus was not confined to China, but it started to spread in other countries, and at the time of writing this article, it has speeded in 222 countries. COVID-19 was declared a pandemic by WHO on 11 March, 2020 (Keni *et al.*, 2020). SARS-CoV-2 belongs to the Coronaviruses (CoVs) family, a diverse family of enveloped positive-single-stranded RNA viruses. Coronaviruses infect humans, mammals, and avian species, including livestock and companion animals (Asaduzzaman *et al.*, 2020). Due to these characteristics, CoVs are becoming a significant threat to the world (Muhammad *et al.*, 2021). If we look into the past, there were two large scale outbreaks over the past two decades, which were severe acute respiratory syndrome (SARS-CoV) that appeared in China in 2002 and spread to 4 other countries. Middle Eastern respiratory syndrome (MERS-CoV) emerged in Saudi Arabia in 2012, and now there is a third ongoing outbreak which is COVID-19 or SARS-CoV-2 (Hozhabri *et al.*, 2020). SARS-CoV-2 is less lethal than MERS-CoV and SARS-CoV, but its transmissibility is very high. Due to these properties, it has a higher prevalence rate and fatalities than its ancestors (Oany *et al.*, 2020).

SARS-CoV-2 can spread from person to person through respiratory transmission, where the virus is suspended in droplets and aerosols expelled from infected individuals (Malik, 2020; Wang *et al.*, 2020) and can also spread through contact with oral, nasal, and eye mucous membranes (Miller *et al.*, 2021). Symptoms of SARS-CoV-2 can range from flu-like symptoms, sore throat, and low-grade fever, similar to the common cold (Channappanavar and Perlman, 2017), to atypical pneumonia characterized by fever, dry cough, dyspnea, hypoxia, chills, rigors, malaise, headache and other severe complications like acute respiratory distress syndrome, pneumonia, systemic inflammation, multiple organ dysfunction, and death (Hui and Zumla, 2019; Hui *et al.*, 2004). Most of the world's population is susceptible to SARS-CoV-2 (Li *et al.*, 2020). SARS-CoV-2 has a high transmissibility rate which is affecting people's health on a large scale and is considered a Pandemic (Lin *et al.*, 2020). Social distancing measures were implemented globally, which included staying 6 feet apart, reducing gatherings, using masks, and remote work and learning (Nicola *et al.*,

2020; Howard *et al.*, 2021). Quarantine and lockdowns were also used to reduce transmission (Koonin, 2020). However, these measures had limited effectiveness in underdeveloped and developing countries due to poverty, weak infrastructure, and limited healthcare resources (Shadmi *et al.*, 2020). The development of a vaccine became a crucial need after the outbreak in 2019 (Jeyanathan *et al.*, 2020). In late 2020, the Pfizer-Biotech COVID-19 vaccine was first approved by the US FDA. Several other vaccines are now available, including AstraZeneca, Sinopharm, Sinovac, Sputnik, CanSinoBio, and others (Noor, 2021; Yan *et al.*, 2021). Approximately 2.5 billion vaccine doses have been rolled out worldwide as of June 18, 2021, with developed countries administering a significant number of doses, including the US, China, India, and Pakistan (BBC News, 2021). A survey was carried out in India to identify the prompt symptoms of the first dose of the COVID-19 vaccine. Five thousand three hundred ninety-six people responded to the survey, and more than half reported at least one post-vaccination symptom from tiredness, myalgia, fever, and headache (Jayadevan *et al.*, 2021). Such surveys can help educate people about vaccination and dispel misinformation regarding the authenticity of vaccines as the COVID-19 vaccination program progresses.

In Pakistan, we know that there is a low vaccination rate. A vast population in Pakistan has been uncooperative towards the COVID-19 outbreak. Despite visualizing the terrible situation of other countries and our own country, people are not taking it thoughtfully. People are also reluctant towards vaccination and have a suspicion towards vaccines. In this research, we will compare the post-vaccination complications among the population. This article will help spread knowledge among the general population about the common side effects of vaccination so they will not be discouraged after getting it. This research will also help spread awareness regarding vaccines' importance in eradicating the COVID-19 pandemic. The primary objective is to evaluate the post-vaccination complications of vaccines on people in Pakistan and to compare the complications of the first and the second doses of COVID-19 vaccines.

## METHODOLOGY

The research study was cross-sectional, conducted near the vicinity of Jinnah Postgraduate Medical Centre, Karachi, started after the IRB approval and ended within nine months. The study was conducted among the general population and only the vaccinated people participated in the study. Age groups between 20-70 years including both male and female were the target population. People who got one dose of vaccine or those who got Cansino vaccine did not participate.

About 325 participants were questioned regarding the complications they experienced after getting the Covid vaccines. The sample size was calculated from OpenEpi software, with a confidence limit of 5%. The data collection was done both manually and through Google forms. Post vaccination complications of COVID-19 vaccines (headache, fever, sore throat, cough, flu, fatigue, diarrhea, muscle ache, abdominal pain, bleeding, allergic reaction) were dependent variables of the study and hypertension, tuberculosis, diabetes, ischemic heart disease, age factor. Immunocompromised patients (patients suffering from any chronic disease) were independent variables of the study (Table 1).

## STATISTICAL ANALYSIS

Data were analyzed through SPSS (Statistical Package for Social Science) version 21. Before entering the data, the data were checked for any errors or outliers and then entered on SPSS. This was the cross-sectional observational study in which we used 95% confidence intervals with level of significance at  $p < 0.05$ . Descriptive data used was frequency of occurrence of symptoms. We analyzed the comparison of post vaccination complications with the help of Mc Nemar test.

## RESULTS AND DISCUSSION

Among three hundred and twenty-five participants, 57.9% experienced complications after the first dose and 48.3% after the second dose. The most common complications were headache, fatigue, and muscle ache, with statistically significant p-values of 0.020, 0.000, and 0.042, respectively. No major complications were reported during the study. The number of participants who experienced each type of complication after the first and second doses is as follows: headache (67 vs 49), fatigue (82 vs 52), fever (65 vs 52), cough (7 vs 7), flu (7 vs 10), sore throat (11 vs 7), nausea (9 vs 6), diarrhea (3 vs 2), pain at the injection site (13 vs 5), muscle ache (125 vs 106), confusion (1 vs 0), asthma (0 vs 1), redness of the eye (1 vs 0), pustules (1 vs 0), abdominal pain (3 vs 5), rash and itching at the injection site (1 vs 0 for the first dose, and 2 for both doses), allergic reaction (1 for both doses), heavy menstrual bleeding (1 for both doses), bleeding at the injection site

(1 vs 2), dizziness (1 vs 0), restricted arm movement (1 for both doses), weakness (0 vs 1), low blood pressure (0 vs 1), and unconsciousness (0 vs 1) (Table 2,3).

Table 1. Demographics.

<b>DEMOGRAPHICS</b>		
		<b>n (%)</b>
<b>AGE</b>	20-40	285 (87.6)
	40 and above	40 (12.4)
<b>GENDER</b>		<b>n (%)</b>
	Male	144 (44.3)
	Female	181 (55.7)
<b>OCCUPATION</b>		<b>n (%)</b>
	Medical Students	159 (48.9)
	Others	95 (29.2)
	Doctors	62 (19.1)
	Pharmacists	8 (2.5)
	Nurses	1 (0.3)
<b>COVID POSITIVE</b>		<b>n (%)</b>
	No	237 (72.9)
	Yes	88 (27.0)
<b>VACCINE NAME</b>		<b>n (%)</b>
	Sinopharm	131 (40.3)
	Sinovac	107 (32.9)
	Moderna	16 (4.9)
	Pfizer	52 (16)
	AstraZeneca	14 (4.3)
	Sputnik V	5 (1.5)

Table 2. Comparison between symptoms of 1st and 2nd Doses of COVID-19 Vaccines and their significance.

VARIABLES	1ST DOSE	2ND DOSE	P-VALUE
	n (%)	n (%)	
Experienced Complications	194 (57.9)	157 (48.3)	0.000
Headache	67 (20.6)	49 (15.1)	0.020
Fatigue	82 (25.2)	52 (16.0)	0.000
Fever	65 (20)	52 (16.0)	0.136
Cough	7 (2.2)	7 (2.2)	1.000
Flu	7 (2.2)	10 (3.1)	0.607
Sore Throat	11 (3.4)	7 (2.2)	0.424
Nausea	9 (2.8)	6 (1.8)	0.549
Diarrhea	3 (0.9)	2 (0.6)	1.000
Pain at injection site	13 (4)	5 (1.5)	0.057
Muscle ache	125 (38.5)	106 (32.6)	0.042
Abdominal Pain	3 (0.9)	5 (1.5)	0.687
Sleepiness	2 (0.6)	2 (0.6)	1.000
Allergic Reaction	1 (0.3)	1 (0.3)	1.000
Heavy Menstrual Bleeding	1 (0.3)	1 (0.3)	1.000
Bleeding at Injection Site	1 (0.3)	2 (0.6)	1.000
Restricted Arm Movement	1 (0.3)	1 (0.3)	1.000

Table 3. Comparison between the frequencies of significant symptoms.

Vaccine Name	Dose	HEADACHE n (%)	FATIGUE n (%)	PAIN AT INJECTION SITE n (%)	MUSCLE ACHE n (%)
Sinopharm	1st dose	25 (37.3)	29 (35)	4 (30.7)	41 (32.8)
	2nd dose	19 (38.7)	16 (30.7)	3 (60)	38 (35.8)
Sinovac	1st Dose	10 (14.9)	18 (21.9)	3 (23.0)	28 (22.4)
	2nd dose	8 (16.3)	8 (15.3)	2 (40)	22 (20.7)
Moderna	1st dose	7 (10.4)	8 (9.0)	1 (7.0)	13 (10.4)
	2nd dose	3 (6.1)	8 (15.3)	0 (0)	12 (11.3)
Pfizer	1st dose	18 (26.8)	21 (25.6)	4 (30.7)	30 (24.0)
	2nd dose	14 (28.5)	15 (28.8)	0 (0)	31 (29.2)
AstraZeneca	1st dose	5 (7.4)	5 (6.0)	1 (7.%)	10 (8.%)
	2nd dose	3 (6.1)	4 (7.6)	0 (%)	2 (1.%)
Sputnik V	1st dose	2 (2.9)	1 (1.2)	0 (%)	3 (2.%)
	2nd dose	2 (4.0)	1 (1.9)	0 (%)	1 (0.%)

Among these participants, 237 (72.9%) participants did not get COVID positive in the past, and only 88 participants got COVID positive. We found that the participants experienced no major health complications, and most complained of headaches, fatigue and muscle ache. A similar study was done on nurses in Turkey to determine the incidence of COVID vaccine (Sinovac) side effects. Three hundred fifty-five nurses who got the Sinovac vaccine participated in the study, and on gathering the information, it was found that the most common side effects reported were pain, fatigue and headache (Bati *et al.*, 2021). The research participants received one of six vaccines: Sinopharm (131 participants, 40.3%), Sinovac (107 participants, 32.9%), Moderna (16 participants, 4.9%), Pfizer (52 participants, 16%), AstraZeneca (14 participants, 4.3%), and Sputnik V (5 participants, 1.5%).

According to a study done in Iran, a case of Longitudinal Extensive Transverse Myelitis(LETM) was reported in a 68 years old female after the first dose of the Sinopharm vaccine (Bagherieh *et al.*, 2022). According to another research in Taiwan, a similar case of LETM was reported in a 78 years old female after vaccination with the Moderna vaccine (Gao *et al.*, 2021). In our research, we did not find any such health problems experienced by the participants.

In another research, a Guillain Barre syndrome(GBS) case was reported in an 82-year-old female after getting the first dose of the Pfizer COVID-19 vaccine. In our research, we did not find any participant developing any severe neurological problems after getting the Pfizer vaccine (Waheed *et al.*, 2021).

The U.S FDA's Center for Biologics Evaluation and Research identified several diseases as Adverse Events of Special Interest (AESIs) for COVID vaccination, including acute myocardial infarction, appendicitis, deep venous thrombosis, Bell's palsy, anaphylaxis, disseminated intravascular coagulation,

encephalomyelitis, hemorrhagic and nonhemorrhagic stroke, immune thrombocytopenia, myocarditis/pericarditis, narcolepsy, pulmonary embolism, and transverse myelitis.

According to a systematic review of 99 studies, about 406 patients complained of cardiovascular and haematological problems. Among these patients, 122 got Pfizer, 44 got Moderna, and 217 got AstraZeneca (Al-Ali *et al.*, 2022). In contrast, none of the individuals in current study exhibited cardiovascular or haematological issues. Present study involved approximately 52 participants who received the Pfizer vaccine, and a subset of these participants reported various health complications. These complications encompassed symptoms such as headache, fatigue, fever, muscle pain, sore throat, flu, cough, nausea, abdominal pain, pain at the injection site, dizziness, restricted arm movement, and swollen axillary lymph nodes. Among the 14 participants who received the AstraZeneca vaccine, those who experienced health complications reported symptoms including headache, fever, fatigue, muscle pain, and pain at the injection site. Moreover, around 16 participants received the Moderna vaccine, and those who encountered health complications reported symptoms such as headache, fever, fatigue, muscle pain, sore throat, nausea, abdominal pain, diarrhea, confusion, and allergic reactions.

## CONCLUSION

The study concludes that no consequential health complications were reported in participants after COVID-19 vaccination. There is a low risk of adverse effects after COVID-19 vaccination. We encourage people to get vaccinated and protect themselves and the people around them from COVID-19.

## REFERENCES

- Asaduzzaman, S. A., A. Zakaria, I. S. Kheya, N. Fahad, Y. B. Sikandar and R. Noor (2020). A comparative study between the severe acute respiratory syndrome–Coronavirus2, severe acute respiratory syndrome coronavirus, and the Middle East respiratory syndrome coronavirus. *Biomedical and Biotechnology Research Journal*, 4(5): 65.
- Al-Ali, D., A. Elshafey, M. Mushannen, H. Kawas, A. Shafiq, N. Mhaimed, ..... and P. Paul (2022). Cardiovascular and hematological events post COVID-19 vaccination: A systematic review. *Journal of Cellular and Molecular Medicine*, 26(3): 636-653.
- By The Visual and Data Journalism Team (2021). Covid vaccines: How fast is progress around the world? BBC News. [cited 19 June 2021]. Available from: <https://www.bbc.com/news/world-56237778>
- Bati, S., R. Burucu, R. Cantekin and H. Dönmez (2021). Determining The Side Effects Of Covid-19 (Sinovac) Vaccination On Nurses; An Independent Descriptive Study. *Konuralp Medical Journal COVID-19*, 479-487 . DOI: 10.18521/kt.981790
- Bagherieh, S., N. Ebrahimi, O. Mirmosayyeb, M. Barzegar and V. Shaygannejad (2022). The First Case of Longitudinal Extensive Transverse Myelitis (LETM) Following the First Dose Vaccination with Sinopharm Vaccine. *Authorea Preprints*, (27).
- Channappanavar, R. and S. Perlman (2017). Pathogenic human coronavirus infections: causes and consequences of cytokine storm and immunopathology. *Seminars in immunopathology*, 39(5): 529–539. <https://doi.org/10.1007/s00281-017-0629-x>
- Chen, C., Y. Zhou and D. W. Wang (2020). SARS-CoV-2: a potential novel etiology of fulminant myocarditis. *Herz*, 45(3): 230–232. <https://doi.org/10.1007/s00059-020-04909-z>
- Gao, J. J., H. P. Tseng, C. L. Lin, J. S. Shiu, M. H. Lee and C. H. Liu (2021). Acute Transverse Myelitis Following COVID-19 Vaccination. *Vaccines*, 9(9): 1008. <https://doi.org/10.3390/vaccines9091008>
- Hozhabri, H., F. Piceci Sparascio, H. Sohrabi, L. Mousavifar, R. Roy, D. Scribano, A. De Luca, C. Ambrosi and M. Sarshar (2020). The Global Emergency of Novel Coronavirus (SARS-CoV-2): An Update of the Current Status and Forecasting. *International Journal of Environmental Research and Public Health*, 17(16): 5648. <https://doi.org/10.3390/ijerph17165648>
- Hui, D. S. C. and A. Zumla (2019). Severe Acute Respiratory Syndrome: Historical, Epidemiologic, and Clinical Features. *Infectious disease clinics of North America*, 33(4): 869–889. <https://doi.org/10.1016/j.idc.2019.07.001>
- Hui, D. S., M. C. Chan, A. K. Wu and P. C. Ng (2004). Severe acute respiratory syndrome (SARS): epidemiology and clinical features. *Postgraduate Medical Journal*, 80(945): 373–381. <https://doi.org/10.1136/pgmj.2004.020263>
- Howard, J., A. Huang, Z. Li, Z. Tufekci, V. Zdimal, H. M. van der Westhuizen, A. von Delft, A. Price, L. Fridman, L. H. Tang, V. Tang, G. L. Watson, C. E. Bax, R. Shaikh, F. Questier, D. Hernandez, L. F.

- Chu, C. M. Ramirez and A. W. Rimoin (2021). An evidence review of face masks against COVID-19. *Proceedings of the National Academy of Sciences of the United States of America*, 118(4): e2014564118. <https://doi.org/10.1073/pnas.2014564118>
- Jeyanathan, M., S. Afkhami, F. Smaill, M. S. Miller, B. D. Lichty and Z. Xing (2020). Immunological considerations for COVID-19 vaccine strategies. *Nature reviews. Immunology*, 20(10): 615–632. <https://doi.org/10.1038/s41577-020-00434-6>
- Jayadevan, R., R. S. Shenoy and T. S. Anitha Devi (2021, January 1). Survey of symptoms following COVID-19 vaccination in India. *Med Rxiv*, 0: 00.
- Keni, R., A. Alexander, P. G. Nayak, J. Mudgal and K. Nandakumar (2020). COVID-19: Emergence, Spread, Possible Treatments, and Global Burden. *Frontiers in Public Health*, 8: 216. <https://doi.org/10.3389/fpubh.2020.00216>
- Koonin L. M. (2020). Novel coronavirus disease (COVID-19) outbreak: Now is the time to refresh pandemic plans. *Journal of Business Continuity and Emergency Planning*, 13(4): 298–312.
- Li, C., F. Ji, L. Wang, L. Wang, J. Hao, M. Dai, Y. Liu, X. Pan, J. Fu, L. Li, G. Yang, J. Yang, X. Yan and B. Gu (2020). Asymptomatic and Human-to-Human Transmission of SARS-CoV-2 in a 2-Family Cluster, Xuzhou, China. *Emerging Infectious Diseases*, 26(7): 1626–1628. <https://doi.org/10.3201/eid2607.200718>
- Lin, D., L. Liu, M. Zhang, Y. Hu, Q. Yang, J. Guo, Y. Guo, Y. Dai, Y. Xu, Y. Cai, X. Chen, Z. Zhang and K. Huang (2020). Co-infections of SARS-CoV-2 with multiple common respiratory pathogens in infected patients. *Science China. Life Sciences*, 63(4): 606–609. <https://doi.org/10.1007/s11427-020-1668-5>
- Muhammad, M., S. A. Ibrahim, I. U. Yarube and B. Bello (2021). A review on emerging pathogenesis of covid-19 and points of concern for research communities in Nigeria. *African Journal of Infectious Diseases*, 15(2): 36–43. <https://doi.org/10.21010/ajid.v15i2.7>
- Malik Y. A. (2020). Properties of Coronavirus and SARS-CoV-2. *The Malaysian Journal of Pathology*, 42(1): 3–11.
- Miller, S. L., W. W. Nazaroff, J. L. Jimenez, A. Boerstra, G. Buonanno, S. J. Dancer, J. Kurnitski, L. C. Marr, L. Morawska and C. Noakes (2021). Transmission of SARS-CoV-2 by inhalation of respiratory aerosol in the Skagit Valley Chorale superspreading event. *Indoor Air*, 31(2): 314–323. <https://doi.org/10.1111/ina.12751>
- Nicola, M., N. O'Neill, C. Sohrabi, M. Khan, M. Agha and R. Agha (2020). Evidence based management guideline for the COVID-19 pandemic - Review article. *International Journal of Surgery (London, England)*, 77, 206–216. <https://doi.org/10.1016/j.ijssu.2020.04.001>
- Noor R. (2021). Developmental Status of the Potential Vaccines for the Mitigation of the COVID-19 Pandemic and a Focus on the Effectiveness of the Pfizer-BioNTech and Moderna mRNA Vaccines. *Current Clinical Microbiology Reports*, 8(3): 178–185. <https://doi.org/10.1007/s40588-021-00162-y>
- Oany, A. R., M. Mia, T. Pervin, M. Junaid, S. M. Z. Hosen and M. A. Moni (2020). Design of novel viral attachment inhibitors of the spike glycoprotein (S) of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) through virtual screening and dynamics. *International Journal of Antimicrobial Agents*, 56(6): 106177. <https://doi.org/10.1016/j.ijantimicag.2020.106177>
- Singhal T. (2020). A Review of Coronavirus Disease-2019 (COVID-19). *Indian Journal of Pediatrics*, 87(4): 281–286. <https://doi.org/10.1007/s12098-020-03263-6>
- Shadmi, E., Y. Chen, I. Dourado, I. Faran-Perach, J. Furler, P. Hangoma, P. Hanvoravongchai, C. Obando, V. Petrosyan, K. D. Rao, A. L. Ruano, L. Shi, L. E. de Souza, S. Spitzer-Shohat, E. Sturgiss, R. Suphanchaimat, M. V. Uribe and S. Willems (2020). Health equity and COVID-19: global perspectives. *International Journal for Equity in Health*, 19(1): 104. <https://doi.org/10.1186/s12939-020-01218-z>
- Wang, Z., W. Ma, X. Zheng, G. Wu and R. Zhang (2020). Household transmission of SARS-CoV-2. *The Journal of Infection*, 81(1): 179–182. <https://doi.org/10.1016/j.jinf.2020.03.040>
- Waheed, S., A. Bayas, F. Hindi, Z. Rizvi and P. S. Espinosa (2021). Neurological Complications of COVID-19: Guillain-Barre Syndrome Following Pfizer COVID-19 Vaccine. *Cureus*, 13(2): e13426. <https://doi.org/10.7759/cureus.13426>
- Yan, Y., Y. Pang, Z. Lyu, R. Wang, X. Wu, C. You, H. Zhao, S. Manickam, E. Lester, T. Wu and C. H. Pang (2021). The COVID-19 Vaccines: Recent Development, Challenges and Prospects. *Vaccines*, 9(4): 349. <https://doi.org/10.3390/vaccines9040349>

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