Proceedings of the Pakistan Academy of Sciences: B
Life and Environmental Sciences 60(3): 377-382 (2023)

ISSN (Print): 2518-4261; ISSN (Online): 2518-427X
http://doi.org/10.53560/PPASB(60-3)749

Pakistan Academy of Sciences

Research Article

An Estimate of Protective Immunity against SARS-CoV2: Comparison of Different Vaccine Types

Waseem Iqbal[1,2], Ikram Ullah[2], Uroosa Irum[3], Saima Siddiqi[4]*, and Khalid Mahmood Khan[5]

[1]Department of Pathology, Mardan Medical Complex Teaching Hospital, Mardan, Pakistan
[2]Department of Medical Lab Technology, The University of Haripur, Haripur, Pakistan
[3]Department of Microbiology, Abdul Wali Khan University Mardan, Pakistan
[4]Department of Rare and Infectious Disease, Institute of Biomedical and Genetic Engineering, Islamabad, Pakistan
[5]University of Agriculture, Faisalabad, Pakistan

Abstract: Several types of vaccines have been approved to prevent SARS-CoV-2 infection. Few studies are conducted on the efficacy of COVID-19 vaccines. Vaccination is important to eliminate and fight SARS-CoV-2 infection and several vaccines have been approved. This study aimed to assess the incidence density of COVID-19 infection among the community, estimate the effectiveness of different types of vaccines (inactivated virus, viral vector or mRNA) and efficiency of incomplete and complete vaccination. In this observational cross-sectional study, a total of 4924 specimens were received from 1st January 2022 to 2nd February 2022 for the detection of SARS-CoV-2. The patient's age, gender, and vaccination data were recorded and S, N, and ORF 1ab genes were amplified after RNA extraction through PCR. out of which 1034 (20.99 %) cases were positive. Among 1034 (20.99 %) positive cases, 418 and 616 patients were vaccinated and non-vaccinated respectively. The cases of SARS-CoV-2 in vaccinated patients were categorized into a sudden infection (≤ 10 days) and late infection (≥10 days) after the incomplete and complete dose of vaccination. Vaccination provides partial protection against SARS-CoV-2 infection. This might be due to the low efficacy and inability to detect recent variations in the protein structure of the virus.

Keywords: SARS-COV-2, Vaccine Effectiveness, COVID-19 Vaccine Types, Ct Value.

1. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2); an emerging infectious disease was first reported at the end of 2019 in Wuhan. Globally SARS-CoV-2 infection has occurred in almost every country with millions infected and hundreds of thousands dead [1]. The treatment and prevention of an infection depend on effective drugs and vaccines. In addition to traditional inactivated vaccines, new technologies are being employed to develop COVID-19 vaccines, such as mRNA/ DNA vaccines, genetically engineered vaccines, and vaccines based on adenovirus-based vectors [2]. For COVID-19, mRNA-based vaccines have shown the highest levels of protection, followed by viral vectors, protein subunits, and whole-inactivated viruses [3].

To eliminate and fight SARS CoV-2 infection, vaccination is important and several COVID-19 vaccines have been approved, including BBIBP-CorV (Sinopharm, China) and CoronaVac (Sinovac Biotech, China) an inactivated virus vaccine with aluminum hydroxide adjuvant of 2 doses are given [4]. CanSino Bio Vaccine/ Ad5-nCoV (China), Gam-COVID-Vac/Sputnik V (Gamaleya National Research Center for Epidemiology and Microbiology, Russia) and ChAd0x1 (AZS1222) (AstraZeneca/ Oxford UK) are viral vector vaccines. mRNA-1273 (Moderna US) and BNT162b2 (Pfizer-BioNTech US) are mRNA vaccines [5, 6]. This study was conducted to determine the

Received: September 2022; Revised: Feberary 2023; Accepted: May 2023
*Corresponding Author: Saima Siddiqi <saimasiddiqi2@gmail.com>

effectiveness of different types of vaccines against COVID-19 and the chances of infection in partially and fully vaccinated individuals.

2. MATERIALS AND METHODS

2.1. Study Design

This observational cross-sectional study was carried out 1st January, 2022 to 2nd February, 2022 at the Department of Pathology, Mardan Medical Complex (MMC). The study population included patients of both genders, age above 20 years, suspected COVID-19 patients (vaccinated and non-vaccinated), Ct values of N, S and ORF1ab genes and those who visited MMC Mardan. Patients having age less than 20 years, asymptomatic, co-infected, or other respiratory disease were excluded from this study.

2.2. Ethical Statement

Ethical approval was obtained from the ethical committee of the hospital, Mardan Medical Complex (MMC) for this study.

2.3. Sample Size

A total of n=1034 COVID-19 positive patients were included in the current study. The patient information such as age, gender, and history of vaccination including vaccine type and vaccination dose (incomplete or complete dose) was recorded through a questionnaire form. COVID-19 positive patients were categorized into 2 groups; sudden infection (≤10 days) and late infection (≥10 days) after the incomplete and complete dose of vaccination.

2.4. Sample Processing

SARS CoV-2 RNA was extracted through an auto extractor (Hangzhou Bigfish Biotech Co Ltd, China) and Real-Time Polymerase Chain Reaction (RT-PCR) was performed for amplification of S, N and ORF 1ab genes (Rotor-Gene, Qiagen, Germany). The cycle threshold (Ct) values of the study patients were categorized as high (Ct 28–34.9) and low (18–27.9). The Ct values were compared between the patients with severe disease and mild disease.

2.5. Statistical Analysis

Quantitative variables such as mean, standard deviation, categorical variables (frequency and percentages) and significance among variables were calculated through SPSS Version 22.0.

3. RESULTS AND DISCUSSION

3.1. Study Population and Characteristics

A total of 4942 specimens of the suspected COVID-19 patients were screened for the detection of SARS-CoV-2. The SARS CoV-2 was detected in 1034 (20.99 %) specimens of the suspected patients through RT-PCR. The demographic data of all the COVID-19 positive patients is tabularized in Table 1. Significant (p value <0.0001) was observed for vaccinated and non-vaccinated patients. The infection rate was significantly high in females than in males, while a non-significant difference was observed between the different age groups (Table 1).vaccinated patients. Incomplete and complete vaccination dose among the vaccinated patients and COVID-19 within ≤ 10 days and after ≥ 10 days of vaccination among incomplete and complete vaccinated patients are shown in Table 2.

3.2. COVID-19 in Vaccinated Patients

Among the Vaccinated patients n=174 (41.62 %) BBIBP-CorV, n=158 (37.79 %) CoronaVac, n=26 (6.2 %) Cansino, n=22 (5.26 %) Sputnik V, n=18 (4.3 %) ChAd0x1 (AZS1222), n=8 (1.91 %) mRNA-1273 and n=12 (2.87 %) BNT162b2.

3.3. N, S and ORF1ab Gene Amplification in COVID-19 Patients

Table 3 shows the ct value (high and low) of different genes; N, S and ORF1ab among the vaccinated and non-vaccinated COVID-19 patients with a p-value of 0.01 (significance). Out of 616 non-vaccinated patients, 504 (81.81 %) had a low Ct value and the rest 112 (18.18 %) had a high Ct value while out of 418 vaccinated patients, 105 (25.11 %) had low Ct value and 313 (74.88 %) had high Ct value (Table 3).

Table 1. Demographic data of COVID -19 vaccinated and non-vaccinated patients

Variables	n (%)	p. value
Total patients	4942	
COVID-19 positive	1034 (20.99)	
COVID-19 negative	3908 (79.366)	<0.0001
Vaccination History		
Vaccinated patients	418 (40.42)	
Non-Vaccinated patients	616 (59.57)	<0.0001
Gender among Positive COVID-19		
Male	667 (64.50)	
Female	367 (35.49)	<0.0001
Vaccination among Positive COVID-19		
Incomplete /Partially vaccinated (1 dose)	198 (47.36)	
Complete /Fully vaccinated (2 doses)	220 (52.63)	0.0152
Gender among Vaccinated patients		
Male	270 (64.59)	
Female	148 (35.40)	<0.0001
Age group of vaccinated Patients		
20-40	126 (30.14)	
41-60	150 (35.88)	0.314
60 & above	142 (33.97)	0.5037
Mean age	**52.58**	

This observational cross-sectional study was carried out from 15 November 2021 to 15 January 2022). We screened a total of 4924 specimens of the suspected COVID-19 patients for detection of SARS-CoV-2, with the incidence of positive samples n= 1034 (21.6 %) patients, out of which n=667 (64.50 %) were males and n=367 (35.49 %) were females. The COVID-19 patients were categorized in three groups according to age: group 1 (21-40 years), group 2 (41-60 years), and group 3 (60 and above). Each group comprised of 126 (30.14 %), 150 (35.88 %) and 142 (33.97 %) patients respectively. The highest number of positive patients were observed in group 2 followed by groups 3 and group 1. The mean age for each group was 30 years, 50.17 years, 75.18 years for group 1, group 2, and group 3 respectively. For all the vaccinated patients the mean age was 52.58 years. A previous study reported that SARS CoV-2 infection was predominant in patients ranging age group 25-44 years followed by the age group higher than 45 years and less than 25 years [7].

Out of 1034 patients, a total of n=418 (40.42 %) were vaccinated and n=616 (59.57 %) were non-vaccinated. Among the vaccinated patients, n=184 (44.01 %) were incomplete vaccinated while n= 234 (55.98 %) were fully/ complete vaccinated. Among the total n=174 (41.62 %) patients vaccinated with BBIBP- CorV vaccine, n= 64 (36.78 %) patients were partially vaccinated (single dose) and n=110 (63.21 %) patients were fully vaccinated (2 doses). A total of n=158 (37.79 %) patients were vaccinated with CoronaVac vaccine (n= 78 (49.36 %) partially vaccinated and n=80 (50.63 %) patients were fully vaccinated). Twenty-six (6.2 %) patients were administered Cansino vaccine. Similarly, n=22 (5.26 %) patients were vaccinated with Sputnik V (n=20 (90.90 %) patients were partially vaccinated and n=2 (9.09 %) patients were fully vaccinated), and n=18 (4.3 %) patients were vaccinated with ChAd0x1 (AZS1222) (n=16 (88.88 %) patients were partially vaccinated and n=2 (11.11 %) patients were fully vaccinated). Eight (1.91 %) patients were vaccinated with mRNA-1273 and none of the patients completed their vaccination dose with mRNA-1273 vaccine, similarly, 12 (2.87 %) patients were vaccinated with BNT162b2 and none of the patients completed their vaccination dose. A similar response was

Table 2. COVID-19 among vaccinated patients (n= 418)

Vaccination Type (n; %)	**COVID-19 infection after Vaccination**	
	Infection within ≤10 days n (%)	**Infection** after ≥ 10 days n (%)
BBIBP- CorV (174; 41.62)		
1 dose (64; 36.78) 2 doses (110; 63.21)	28 (43.75) 2 (1.81)	36 (56.25) 108 (98.18)
CoronaVac (158; 37.79)		
1 dose (78; 49.36) 2 doses (80; 50.63)	70 (89.74) 4 (5)	8 (10.25) 76 (95)
Cansino (26; 6.2)		
1 dose (26; 100)	0	26 (100)
Sputnik V (22; 5.26)		
1 dose (20; 90.90) 2 doses (2; 9.09)	0 0	20 (100) 2 (100)
ChAd0x1 (AZS1222) (18; 4.3)		
1 dose (16; 88.88) 2 doses (2; 11.11)	0 0	16 (100) 2 (100)
mRNA-1273 (8; 1.91)		
1dose (8; 100)	0	8 (100)
BNT162b2 (12; 2.87)		
1 dose (12; 100)	0	12 (100)

observed in another study in patients who were not vaccinated with an mRNA vaccine had 2.34-fold higher odds of reinfection compared with fully vaccinated adults [8].

Among BBIBP-CorV vaccinated patients with incomplete dose, 28 (43.75 %) patients were diagnosed with COVID-19 within ≤ 10 days and n=36 (56.25 %) were diagnosed with COVID-19 after ≥ 10 days of vaccination while BBIBP-CorV vaccinated patients with complete dose were 2 (1.81 %) within ≤ 10 days and 108 (98.18 %) after ≥ 10 days of vaccination.

Out of n=78 CoronaVac partially vaccinated patients, n=70 (89.74 %) patients were diagnosed with COVID-19 within ≤ 10 days and n=8 (10.25 %) were diagnosed with COVID-19 after ≥ 10 days of vaccination whereas CoronaVac fully vaccinated patients, 4 (5 %) patients were diagnosed COVID-19 within ≤ 10 days and 76 (95 %) after ≥ 10 days of vaccination.

None of the patients were infected with SARS CoV-2 after the incomplete and complete dose of Sputnik V vaccination within ≤ 10 days. All patients n=20 (100 %) and n=2 (100 %) were COVID-19 positive after ≥ 10 days of vaccination, similarly, none of the patients was COVID-19 positive after the incomplete and complete dose of Astrazeneca vaccination within ≤ 10 days. n=16 (100 %) and n=2 (100 %) had COVID-19 after the incomplete and complete dose of ChAd0x1 (AZS1222) vaccination after ≥ 10 days. Patients incomplete vaccinated with mRNA-1273 (n=4) and BNT162b2 (n=6) were COVID-19 positive after ≥ 10 days. Another study has reported COVID-19 vaccines to offer protection against SARS CoV-2 variants, including Delta, after completion of the vaccination series, and the effect of partial uptake of vaccines is found to be suboptimal [9,10].

Ct values of gene N, S and ORF1ab were calculated among all the positive COVID-19 patients (vaccinated and non-vaccinated). The Ct values of patients with high viral load were significantly lower than patients with low viral load. Out of 616 non vaccinated patients with high viral

Table 3. Comparison of mean Ct values between vaccinated and non-vaccinated patients

COVID-19 Patients (n; %)	Genes	High Ct value Mean	Low Ct value mean	Significance testing
Non-vaccinated (n=616; 59.57)	N	31.647	25.291	p=0.01
	S	32.011	26.132	
	ORF1ab	32.821	26.781	
Vaccinated (n= 418; 40.42)	N	32.196	26.543	p=0.01
	S	32.733	26.962	
	ORF1ab	33.228	27.341	

load, n=504 (81.81 %) had Ct value <27 (n= 113 (22.42 %) Ct value 18-22.9 and n=391 (77.57 %) Ct value 23-27.9) and n=112 (18.18 %) with low viral load had Ct value > 27 (n=50 (44.64 %) Ct value 28-30.9) and n=62 (55.35 %) Ct value 31-34.9).

In total of 418 vaccinated patients, n=105 (25.11 %) had Ct value <29 (n=40 (38.09 %) Ct value 24.1-27.9 and n=65 (61.90 %) had Ct value 28-29.9), while 313 (74.88 %) low viral load patients had Ct value > 29 (n=63 (20.12 %) with Ct 28-30.9 and n=250 (79.87 %) with Ct 31-34.9). A significant difference was found in viral load and Ct values of the vaccinated and non-vaccinated patients (p=0.01). In the current study we categorized Ct values of as high (>29) and low (<29). Another study has grouped patients on the basis of Ct values as high (Ct 31–40), moderate (21–30) and low (11–20) [11].

4. CONCLUSION

Vaccination provides partial protection against SARS COV-2. This might be due to the low efficiency and potential to detect recent variations in the protein structure of the virus. Furthermore, incomplete vaccination in the community also increases the risk of COVID-19. The study also concluded that chances of SARS-CoV-2 infection (sudden and late) are high in patients vaccinated with inactivated vaccines (Sinopharm and Sinovac). To our knowledge, this is the first study to describe the effectiveness of different types of vaccines against COVID-19 and reported COVID-19 within ≥ 10 days or more ≤ 10 days among incomplete and complete vaccination doses.

5. LIMITATIONS

The limitations of this study were the lack of follow-up of all the vaccinated patients, study duration was short, lack of clinical correlation among the vaccinated patients and COVID-19 variants were not detected and Ct values among incomplete and complete vaccination in vaccinated patients were not calculated.

6. RECOMMENDATIONS

Vaccines needs to be updated periodically to increase clinical efficacy against SARS CoV-2 variants and detection of SARS CoV-2 infection and other complications at the time of vaccination is needed to overcome the efficiency and effectiveness of vaccine among COVID-19 patients.

7. CONFLICT OF INTEREST

The authors declared no conflict of interest.

8. REFERENCES

1. K. Dooling, M. Marin, M. Wallace, N. McClung, M. Chamberland, G.M. Lee, H.K. Talbot, J.R. Romero, B.P. Bell, and S.E. Oliver. The Advisory Committee on Immunization Practices updated interim recommendation for allocation of COVID-19 vaccine-United States, December 2020. *Morbidity and Mortality Weekly Report (MMWR)* 69:1657-1660 (2021).
2. J.S. Tregoning, E.S. Brown, H.M. Cheeseman, K.E. Flight, S.L. Higham, N.M. Lemm, B.F. Pierce, D.C. Stirling, Z. Wang, and K.M. Pollock. Vaccines for COVID-19. *Clinical and Experimental Immunology* 202(2): 162-192 (2020).

3. A. Callegaro, D. Borleri, C. Farina, G. Napolitano, D. Valenti, M. Rizzi, and F. Maggiolo. Antibody response to SARS-CoV-2 vaccination is extremely vivacious in subjects with previous SARS Cov-2 infection. *Journal of Medical Virology* 93: 4612-4615 (2021).
4. S. Malhotra, K. Mani, R. Lodha, S. Bakhshi, V.P. Mathur, P. Gupta, S. Kedia, J. Sankar, P. Kumar, A. Kumar, V. Ahuja, S. Sinha, R. Guleria, A. Dua, S. Ahmad, R. Sathiyamoorthy, A. Sharma, T. Sakya, V. Gaur, S. Chaudhary, S. Sharma, D. Madan, A. Gupta, S. Virmani, A. Gupta, N. Yadav, S. Sachdeva, S. Sharma, S. Singh, A. Pandey, M. Singh, D. Jhurani, S. Sarkar, A.K. Lokade, A. Mohammad, S. Pandit, R. Dubey, A.K. Singh, N. Gohar, D. Soni, A. Bhattacharyya, S. Rai, S. Tummala, I. Gupta, and S. Shukla. SARS-CoV-2. Reinfection Rate and Estimated Effectiveness of the Inactivated Whole Virion Vaccine BBV152 Against Reinfection Among Health Care Workers in New Delhi, India. *JAMA network* 5(1): e2142210 (2022).
5. F.C. Zhu, X.H. Guan, Y.H. Li, J.Y. Huang, T. Jiang, L.H. Hou, J.X. Li, B.F. Yang, L. Wang, W.J. Wang, S.P. Wu, Z. Wang, X.H. Wu, J.J. Xu, Z. Zhang, S.Y. Jia, B.S. Wang, Y. Hu, J.J. Liu, J. Zhang, X.A. Qian, Q. Li, H.Y. Pan, H.D Jiang, P. Deng, J.B. Gou, X.W. Wang, X.H. Wang, and W. Chen. Immunogenicity and safety of a recombinant of adeno virus type five vectored COVID-19 vaccine in healthy adults aged 18 years or older: a randomized, double-blind, placebo-controlled, phase 2 trial. *Lancet* 396: 479-488 (2020).
6. O. Sharma, A.A. Sultan, H. Ding, and C.R. Triggle. A Review of the Progress and Challenges of Developing a Vaccine for COVID-19. *Frontiers in immunology* 11: 585354 (2020).
7. K.E. Stephenson, M.L. Gars, J. Sadoff, A.M. de-Groot, D. Heerwegh, C. Truyers, C. Atyeo, C. Loos, A. Chandrashekar, K. McMahan, L.H. Tostanoski, J. Yu, M.S. Gebre, C. Jacob-Dolan, Z. Li, S. Patel, L. Peter, J. Liu, E.N. Borducchi, J.P. Nkolola, M. Souza, C.S. Tan, R. Zash, B. Julg, R.R. Nathavitharana, R.L. Shapiro, A.A. Azim, C.D. Alonso, K. Jaegle, J.L. Ansel, D.G. Kanjilal, C.J. Guiney, C. Bradshaw, A. Tyler, T. Makoni, K.E. Yanosick, M.S. Seaman, D.A. Lauffenburger, G. Alter, F. Struyf, M. Douoguih, J.V. Hoof, H. Schuitemaker, and D.H. Barouch. Immunogenicity of the Ad26.COV2.S vaccine for COVID-19. Journal of the American *Medical Association (JAMA)* 325:1535-1544 (2021).
8. A.M. Cavanaugh, K.B. Spicer, D. Thoroughman, C. Glick, and K. Winter. Reduced risk of reinfection with SARS-CoV-2 After COVID-19 vaccination - Kentucky, May-June 2021. Morbidity and *Mortality Weekly Report (MMWR)* 70(32):1081-1083 (2021).
9. J.L. Bernal, N. Andrews, C. Gower, E. Gallagher, R. Simmons, S. Thelwall, J. Stowe, E. Tessier, N. Groves, G. Dabrera, R. Myers, C.N.J. Campbell, G. Amirthalingam, M. Edmunds, M. Zambon, K.E. Brown, S. Hopkins, M. Chand, and M. Ramsay. Effectiveness of COVID-19 vaccines against the B.1.617.2 (Delta) variant. *The New England Journal of Medicine* 385(7): 585-594 (2021).
10. D. Desai, A.R. Khan, M. Soneja, A. Mittal, S. Naik, P. Kodan, A. Mandal, G.T. Maher, R. Kumar, A. Agarwal, N.R. Gowda, H. Vikas, P. Kumar, S. Pandey, R.M. Pandey, A. Kumar, A. Ray, P. Jorwal, N. Nischal, A. Choudhary, M. Brijwal, K. Madan, R. Lodha, S. Sinha, L. Dar, N. Wig, and R. Guleria. Effectiveness of an inactivated virus-based SARS-CoV-2 vaccine, BBV152, in India: a test-negative, case-control study. *Lancet. Infectious diseases* 22(3): 349-356 (2022).
11. S. Shah, T. Singhal, N. Davar, and P. Thakkar. No correlation between Ct values and severity of disease or mortality in patients with COVID 19 disease. Indian Journal of Medical *Microbiology* 39(1): 116-117 (2021).