International Journal of Medical Science and Clinical Research Studies

ISSN(print): 2767-8326, ISSN(online): 2767-8342

Volume 04 Issue 08 August 2024

Page No: 1489-1503

DOI: https://doi.org/10.47191/ijmscrs/v4-i08-13, Impact Factor: 7.949

Sarscov-2 Antibody Response to COVID-19 MRNA Vaccine in 2024 among Health Care Workers Working in one Selected Public Hospital from Myanmar

Khin Phyu Pyar*[1], Aung Phyoe Kyaw[2], Kaung Myat Oo[3], Thein Tun Myint[2], Kyaw Thet Maung[2], Kyaw Zaya[2], Aung Thu[2], Han Lin Aung[2], Saw Tha Wah[2], Myo Thant Kyaw[2], Aung Phyo Latt[2], Zay Phyo Aung[2], Sitt Min[2], Win Min Tun[2], Aung Htoo Kyaw[2], Sai Su Phone[2], Ye Min Thu[2], Nyan Naing Soe[2], Wai Lynn Aung[2], Thant Zin Lynn[2]

[1]Professor and Head/ Senior Consultant Physician, Department of Medicine/Nephrology, Defence Services Medical Academy/ No. (1) Defence Services General Hospital (1,000 Bedded), Yangon, Myanmar

[2]Senior Consultant Physician, No. (1) Defence Services General Hospital (1000-Bedded), Yangon, Myanmar

[3]Consultant Pathologist, No. (1) Defence Services General Hospital (1000-Bedded), Yangon, Myanmar.

ABSTRACT

Background: The health care workers have been handling with patients who may have symptomatic or asymptomatic coronavirus disease (COVID-19) since 2019. SARS-CoV-2 virus has been producing several variants. (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran was available in Myanmar in January 2024. This study aimed to assess changes in SARSCoV-2 antibody level in health care workers (HCW) following COVID-19 mRNA Vaccine and to determine the factors influencing antibody response.

Methods: An analytic study was conducted in Defense Services General Hospital (1,000 Bedded) in Myanmar in 2024. SARSCoV-2 antibody level was measured twice; prior to COVID-19 mRNA Vaccine and 70 days after vaccination. Data were collected by using standardized forms and analysis was done.

Results: A total of 99 HCW were included. All HCW had anti-Spike antibody prior to COVID-19 mRNA Vaccine (basal level); and the minimum level was 904 U/mL. Minimum antibody level as well as mean antibody level became double on Day '70' after vaccination. Mean basal anti-Spike antibody level was 4,195.04 ± 2898.20 U/mL; it rose to 9,115.31± 3518.89 U/mL on Day '70'. Female had higher basal anti-Spike antibody level as well as the antibody level on Day '70' than male; the basal level was 7,365 ± 5,460.97 U/mL and 3,878.04 ± 2,334.64 U/mL; and, 'Day 70' level was 10,404.67±4,725.860 U/mL and 8,894.85±3,487.904 U/mL respectively. HCW aged over 40 years had higher basal anti-Spike antibody level than that of under 40 years; 5,634.42 ± 3,801.08 U/mL and 3,538.85 ± 2,102.61 U/mL respectively. However, on Day '70', younger age group had better response; 9,564.37±3,265.608 U/mL in younger age group and 7,864.55±4,098.874 U/mL in older age group.

Antibody level on 'Day 70' was higher in HCW without comorbid disease and HCW with COVID symptoms at the time of vaccination. History of COVID-19 in past 6 months to 1 year prior to COVID-19 mRNA Vaccine did not influence the antibody response. The basal antibody level was lowest in underweight group (2,327.00±668.00 U/mL) and highest in overweight group 5,019.26±3,485.20 U/mL. On 'Day 70', the highest level 9,225.03±3,416.99 U/mL was recorded in normal weight group; it was followed by overweight group.

Conclusions: All HCW had had acquired immunity to SARSCoV-2 virus in January 2024. Their SARSCoV-2 antibody level became double on Day '70' after one dose of (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran. Younger age group, female, HCW without comorbid disease, those with normal weight and overweight group, and presence of COVID

ARTICLE DETAILS

Published On:
13 August 2024

symptoms at the time of vaccination had better antibody response. Antibody response was not related with history of COVID-19 in past 6 months to 1 year. One dose of COVID-19 mRNA Vaccine was 100% effective in promoting anti-Spike antibody.

KEYWORDS: SARSCoV-2 antibody, COVID-19, health care workers (HCW), (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran

Available on:
https://ijmscr.org/

BACKGROUND

Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. SARS-CoV-2 virus has been infecting since 2019; and we have been fighting it through vaccination. COVID-19 rapidly emerged as a leading cause of death; it was the third highest cause of mortality globally in 2020 and the second in 2021 (WHO report May 2024). Vaccination remains the most effective tool for the prevention of COVID-19 (Tannous et al., 2023).

In 2024, some countries have declared herd immunity with booster vaccination. Even, minor protective measures like wearing mask in public areas are not enforced in most of the countries. Most of the people believe that they are immune to SARSCoV-2 virus; and, screening to SARSCoV-2 virus is not done even for fever cases and cases with respiratory symptoms. However, there are sporadic cases in both public and private hospital; some cases are fatal if they are associated with comorbid diseases.

SARS-CoV-2 virus stimulates our immune system to produce anti-body. On the other hand, vaccination produces antibody level too. Studies reported that combination of innate immunity and vaccine-induced immunity resulted in boost immunity. Cheetham et al pointed out that the association between antibody level to SARSCoV-2 virus and risk of subsequent infection; and it was a good guidance to triple vaccination (Cheetham et al., 2023).

SARS-CoV-2 virus has been circulating and evolving for 4 years; there are genetic changes in important regions of the spike protein of SARS-CoV-2 virus with resultant several variants. As of April 2024, nearly all SARS-CoV-2 genetic sequences are derived from JN.1, and these variants continue to displace existing XBB lineage variants (WHO April 2024). Therefore, an updated vaccine antigen plays an important role. If it is added with an additional vaccine dose, an average 40% increase in neutralizing antibodies to that particular variant compared to vaccines with a previous vaccine antigen (WHO April 2024). According to Hwang et al, the antibody response to murine monoclonal antibodies (mAbs) against the SARS-CoV may give better information to immunity (Berry et al., 2004) (Hwang et al., 2022). As SARS-CoV-2 virus has been producing several variants; deep learning for specific variant is necessary (Lim et al., 2023) (Lim et al., 2023) (Torres et al., 2022).

The health care workers (HCW) may acquire coronavirus disease (COVID-19) though they adhere to personnel protective measures and are fully vaccinated. And, the infection may be asymptomatic. On the other hand, they are handling patients with fever as well as asymptomatic coronavirus disease (COVID-19) coming for other reasons. Several studies reported COVID-19 break through infection among HCW; the prevalence varied with type of vaccine, country, study site and the type of variant (Sharma et al., 2021) (Tyagi et al., 2021) (Niyas & Arjun, 2021). Previous report from Myanmar pointed out that one in four physicians had break through infection in 2021 though they had two doses of vaccine (Pyar et al., 2021). Moreover, break through infection due to the Omicron variant was reported from Myanmar in early 2022 (Pyar, 2022).

In 2024, 5 years after pandemic, (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran was available in Myanmar. Covidshield, Covaxin, Sinopharm and Sinovax were given to public from 2020 to 2023. As of 2023, 80% of population were vaccinated. A two-dose regimen of COVID-19 mRNA Vaccine BNT162b2 conferred 95% protection against COVID-19 in adults.The emergence of new virus variants can lead to reduced vaccine effectiveness and the need for new vaccines or vaccine doses if the extent of immune evasion is severe. Neutralizing antibody titers was said to be correlated with protection for SARS-CoV-2; it estimated vaccine effectiveness for new variants (Gardner & Kilpatrick, 2024). The antibody level depended on several factors like age, sex, BMI(Pyar et al., 2022), comorbid diseases (Pyar et al., 2023)and severity of COVID-19.Therefore, it was important to know antibody response to (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran in 2024. This study aimed to assess the changes in level of anti-Spike antibody among health care workers (HCW) 70 days after (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran and to determine the factors influencing antibody response.

METHODS

Study design and population

An analytic study was conducted from January 2024 to May 2024 to HCW working in public hospital. Informed consent was taken from each HCW. This study was approved by the Hospital Research and Ethics Committee of No.(1) Defence Services General Hospital (1000-Bedded) Mingaladon, Yangon.

Data collection and procedure

Demographic characteristics (sex, age, height, weight) and comorbidity (hypertension, diabetes mellitus, bronchial asthma etc) were collected using a standardized case report form. The date of (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran vaccination, timing of previous COVID-19, symptoms of COVID-19 were recorded. The blood was taken twice to measure level of anti-Spike antibody level; first sample was taken prior to vaccination and second sample was 70 days after vaccine. The data were checked by two medical officers and then, supervision, completeness, and consistency of collected data were performed by the principle investigator.

Anti-Spike antibody was measured according to **'**Double-antigen sandwich principle'. Total duration of assay was 18 minutes. For first incubation, 20 µL of sample, biotinylated SARS-CoV-2 S-RBD-specific recombinant antigen and SARS-CoV-2 S-RBD-specific recombinant antigen labeled with a ruthenium complex) were done to form a sandwich complex. Then, second incubation was performed after addition of streptavidin-coated microparticles, the complex becomes bound to the solid phase via interaction of biotin and streptavidin. The reaction mixture was aspirated into the measuring cell where the microparticles were magnetically captured onto the surface of the electrode. Next, unbound substances were removed with ProCell/ProCell M. Later, application of a voltage to the electrode to induce chemiluminescent emission was done; it was measured by a photomultiplier. Finally, the results were determined via a calibration curve, instrument specifically generated by 2-point calibration; and, a master curve was provided via the reagent barcode or e-barcode. These samples were measured by using Cobas E411 immunoassay analyzer.

Working Definition

Coronavirus disease was defined as COVID-19 according to WHO.

Body mass index (BMI) was a person's weight in kilograms divided by the square of height in meters, an indicator of body fatness. BMI was categorized as underweight group (< 18.5 kg/m^2), normal weight group (18.5 to 24.9 kg/m^2), overweight group (25.0 to 29.9 kg/m^2) and (≥ 30.0 kg/m^2) obese group.

History of COVID-19 was defined if HCW had signs and symptoms of COVID-19 with positive nasopharyngeal swab tests either with rapid test or PCR method in past 6 months to one year. Comorbidity was a presence of more or additional medical conditions or diseases like hypertension, diabetes mellitus, bronchial asthma, ischemic heart disease, rheumatic heart disease or thyroid diseases in HCW.

Symptoms of COVID-19 was defined as HCW had fever, sore throat, cough, myalgia, arthralgia with or without diarrhea or anosmia.

(Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran was COVID-19 mRNA Vaccine similar to BNT162b2 vaccine (Pfizer-BioNTech) and the expiry date was 30 August 2024.

Basal anti-Spike antibody level was defined as anti-Spike antibody level measured in HCW prior to (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran vaccination.

'Day 70' anti-Spike antibody level was defined as anti-Spike antibody level measured in HCW '70' days after (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran vaccination.

Statistical Analysis

Total samples of 99 were analyzed by SPSS version 26.0 for MacOS. Descriptive statistics was done, continuous variables were assessed normality by Shapiro-Wilk test. Normally distributed data were expressed in mean ± SD and non-normal data were expressed as Median (IQR). Categorical data were expressed in frequency and percentage. Antibody differences between sex, age, comorbid diseases, COVID-19 symptoms and history of COVID-19 were compared by independent t test, BMI groups by one way ANOVA test and expressed in mean ± SD, and differences between co-morbid status were assessed by Mann-Whitney U test. Univariable and multivariable analysis was used by linear regression. P value < 0.05 was used as significant level.

RESULTS

An analytic study was conducted in 2024 among health care workers (HCW) who received (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran. A total of 99 HCW were included. As shown in table (1), most of the HCW were male; male to female ration was 10:1. The mean age was 34.87±9.02 years; the youngest was 20 years and the oldest was 61 years. Thirteen HCW had comorbid diseases: diabetes mellitus (3/13); obesity and hypertension (2/13); hypertension (5/13); bronchial asthma (1/13); hypothyroid (1/13) and rheumatic mitral stenosis (1/13).

As shown in table (2), basal anti-Spike antibody level in HCW aged over 40 years was larger than that of age under 40 years;

5634.42 ± 3801.08 U/mL and 3538.85 ± 2102.61U/mL respectively. Nonetheless, the response to vaccine gave greater level in younger age group (9564.37±3265.608 U/mL) than older age group (7864.55±4098.874 U/mL). It was statistically significant. It can be seen in table (4).

Female had higher level of basal anti-Spike antibody (7365 ± 5460.97 U/mL) significantly than male (3878.04 ± 2334.64 U/mL). On 'Day 70', the antibody level of female was still higher though it was not significant; 10404.67±4725.860 U/mL in female and 8894.85±3487.904 U/mL in male. Table (2) and (4) demonstrate them.

As shown in table (2), anti-Spike antibody level in HCW with comorbid diseases had higher level (5038.38 ±4301.14 U/mL) than those HCW without comorbid diseases (4067.56±2635.76 U/mL); however, it was not significant (p=0.26). As revealed in table (4), the antibody level on 'Day 70' showed that those without comorbidity had higher level than that of those with comorbid diseases; 9118.37±3592.362 U/mL and 8461.46±3854.047 U/mL respectively.

History of COVID-19 in past 6 months to 1 year was recorded in 74% (73/99) of HCW. It is illustrated in table (1). Among them, 48(48.5%) had clinical COVID-19 symptoms; 17 (17.2%) had clinical COVID-19 symptoms with positive rapid test; and 8 (8.1%) had clinical COVID-19 symptoms with positive PCR test. None of them developed severe infection and treated with symptomatic treatment in 95% (71/73). The basal antibody level in two groups (HCW with history of COVID-19 infection 6 months to one year and those who did not infection) was not different (4059.10 ± 2845.44 U/mL vs. 4576.73 ± 3066.46 U/mL). On 'Day 70', those without history of COVID-19 had higher antibody level than those without COVID-19; 10086.46±3562.65 U/mL and 8656.58±3581.47 U/mL respectively. They are demonstrated in table (2) and (4).

One tenth of them were having COVID-19 symptoms at the time of vaccination as seen in table (1). Their basal antibody level was higher (5066.88 ± 4004.35 U/mL) than that of those without COVID-19 symptoms (4118.40 ± 2797.42 U/mL). The same pattern was seen in 'Day 70'antibody level; 9225.25±3426.82 U/mL and 9015.13±3647.71 U/mL respectively. They are revealed in table (2) and (4).

The mean basal anti-Spike antibody level was 4195.04 ± 2898.20 U/mL and that of 'Day 70' was 9115.31± 3518.89 U/mL. Minimum antibody level as well as mean antibody level became double on Day '70' after vaccination. It is clearly seen in figure (3); comparison of COVID antibodies level between baseline and 'Day 70'.

Their mean BMI was 24.19 ± 3.20 kg/m^2 as shown in table (1). Majority of HCW were in normal weight group (18.5 to 24.9 kg/m^2) (40%) and overweight group (25.0 to 29.9 kg/m^2) (50%). Those with high BMI had higher level of antibody on univariable analysis (R^2 = 0.009); however, it was not significant. It is illustrated in figure (1); correlation between BMI status and baseline COVID-19 antibody level. Figure (2) demonstrates correlation between BMI status and antibody level at 'Day 70'. There was no correlation.

Table (2) reveals basal antibody level among various BMI groups. Figure (4) illustrates correlation between BMI groups and antibody level at 'Day 70' Those HCW in underweight group (< 18.5 kg/m^2) had the lowest basal antibody level (2327.00±668.00 U/mL). On the other hand, the basal antibody level was highest in those with overweight group (25.0 to 29.9 kg/m^2) (5019.26±3485.20 U/mL).

On 'Day 70', the antibody level increased twofold in all BMI groups as illustrated in table (3) and figure (5). The highest level 9225.03±3416.99 was recorded in normal weight group (18.5 to 24.9 kg/m^2) followed by overweight group (25.0 to 29.9 kg/m^2).

DISCUSSION

Coronavirus Disease 2019 (COVID-19) has been the most severe public health challenge in this century. Two years after its emergence, the rapid development and deployment of effective COVID-19 vaccines have successfully controlled this pandemic and greatly reduced the risk of severe illness and death associated with COVID-19. As the SARS-CoV-2 virus may never be eradicated, and we have to live with this virus for a long time (Chi et al., 2022). Therefore, this study may reflect the immune response to one dose of (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran in year 2024 among HCW from Myanmar.

This descriptive study involved 99 HCW working in public hospital (1,000 bedded) in Yangon, Myanmar. The study was done from January to April 2024. There were sporadic case reports on non-severe cases as well as severe cases of COVID-19 in 2024 (WHO epidemiological update may 2024).

Having antibody level prior to vaccination in all HCW showed relatively good immunity though only two third of them had history of COVID-19 in past 6 months to 1 year. The development of several vaccines and the success of passive immunotherapy may boost the immunity of HCW. According to Hajissa et al, anti-SARS-CoV-2 antibodies are useful in the treatment and prevention of SARS-CoV-2 infection. It is also important in surveillance of COVID-19 (Hajissa et al., 2022) (Althoff et al., 2022) (Kim et al., 2024) (Sumpaico-Tanchanco et al., 2022). Therefore, having basal antibody level in 100% of HCW in this study not only reflected the disease burden of COVID-19 in Myanmar (Li et al., 2022). It also indicated the immune status to SARS-CoV-2 virus in the community (Anichini et al., 2021) (Alejo et al., 2022) because all HCW were living and mixing with people in the community.

The diagnosis of COVID-19 based on SARS-CoV-2 PCR testing or rapid testing of pharyngeal or respiratory specimens in a symptomatic patient; therefore, it might underestimates the true prevalence of infection. Serologic methods can more accurately estimate the disease burden by detecting infections missed by the limited testing (pharyngeal swab or nasal swab) performed to date. The antibody responses to COVID-19 may be either due to SARS-CoV-2 virus acquired or COVID-19 vaccine related; and, it may be combined effect. The report by de Assis et al highlighted that antibody responses can be used as a diagnostic tool as well as an epidemiologic tool to more accurately estimate the disease burden of COVID-19 (de Assis et al., 2020) (Sumpaico-Tanchanco et al., 2022).

In this study, all HCW had anti-Spike antibody; minimum 904 U/mL to maximum 12500 U/mL. They had COVID-19 vaccine 4 times within 2-3 years prior to antibody testing; and, 75% of them had history of COVID-19 6 months to one year ago. It explained clearly the fact that HCW involved in this study had 100% immunity. The antibody level reflected the prevalence of COVID-19 and the duration of immunity (Alejo et al., 2022). This study may reflect the immune status of HCW working in public hospital; it indicated that SARS-CoV-2 virus is still living with us in 2024. It is important for clinicians to aware COVID-19 in those with comorbid diseases having respiratory symptoms and respiratory failure.

Basal anti-Spike antibody level became double on 'Day 70'. The immunity increases with increasing exposure to SARS-CoV-2 virus and vaccination. The findings from Bangladesh showed that vaccine-mediated protection from (re)infection partially linked to elevated levels of S-specific antibodies (Haq et al., 2024). A two-dose regimen of BNT162b2, similar COVID-19 mRNA Vaccine, conferred 95% protection against Covid-19 in persons 16 years of age or older. The emergence of new virus variants can lead to reduced vaccine effectiveness and the need for new vaccines or vaccine doses if the extent of immune evasion is severe. Neutralizing antibody titers have been shown to be a correlate of protection for SARS-CoV-2 and other pathogens, and could be used to quickly estimate vaccine effectiveness for new variants. (Gardner & Kilpatrick, 2024). According to Hogan et al, the immunogenicity data could predict vaccine effectiveness (Hogan et al., 2023) (Tannous et al., 2023). Therefore, one dose of (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran, similar to BNT162b2 vaccine (Pfizer-BioNTech), was 100% effective in boosting antibody level in HCW working in public hospital.

In this study, HCW aged over 40 years had significantly higher basal anti-Spike antibody level than those younger than 40 years. Nonetheless, younger age group had higher antibody level on 'Day 70'. Therefore, it confirmed previous report 'older age group had lower antibody response' (Ward et al., 2022) (Wang et al., 2019) (Karamese & Tutuncu, 2022) (Müller et al., 2021).

However, this study confirmed the report that neutralizing antibodies correlate positively with age, male sex, and severity of the disease (*Antibody Responses in COVID-19: A Review*, n.d.). It was arguable that antibody response had high interindividual variation; and, the antibody titer decreased over time (Higgins Victoria et al., 2021) (Bruxvoort et al., 2021).

Regarding the response in sex, female had significantly higher basal anti-Spike antibody level than male in this study. Moreover, the antibody level on 'Day 70' was larger in female than male. Similar finding was found Myanmar in 2022 though it was not significant (KPPyar et al., 2022). Therefore, it proved that female had higher antibody positivity following COVID-19 vaccination (Ward et al., 2022) (Wang et al., 2019). Nonetheless, this study was contrary to the fact that neutralizing antibodies correlate positively with male sex (*Antibody Responses in COVID-19: A Review*, n.d.).

In view of the effect of comorbid disease on anti-Spike antibody level, HCW with comorbid disease had slightly higher basal level than those HCW without comorbid disease. Previous study in Myanmar revealed that HCW with diabetes mellitus had significantly higher level of anti-Spike antibody level than those without diabetes (Pyar et al., 2023). The antibody level on 'Day 70' showed that HCW without comorbidity had higher level than that of those with comorbid diseases; Therefore, this study supported other reports; patients with comorbidity had low antibody response to COVID-19 vaccine (Ward et al., 2022)(Rangsrisaeneepitak et al., 2022) (Karamese & Tutuncu, 2022) (Müller et al., 2021).

Those HCW having symptoms of COVID-19 at the time of antibody testing had slightly higher basal level than those who were normal; the same finding on 'Day 70'. It supported the fact that there was association between antibody level and infection (Cheetham et al., 2023). Generally, antibody begin to rise within the first few days following an infection with COVID-19 or after the vaccine. Later, the level steadily increase in concentration till 6 months; then, they decline gradually (Ortega et al., 2021). The effect of hybrid immunity is related with exact timing (Anichini et al., 2021) (Rodda et al., 2022) (Higgins Victoria et al., 2021) (Menegale et al., 2023). In this study, the basal antibody level of HCW with known COVID-19 in last 6 months to one year was not different significantly from that of HCW without infection. On 'Day 70', those without history of COVID-19 had higher antibody level than those without COVID-19. It may be due to several factors; (1) all HCW may have asymptomatic COVID-19 producing passive immunity; (2) all HCW had completed vaccination 4 doses in previous 2-3 years reflecting active immunity(Anichini et al., 2021); (3) the

effect of hybrid immunity in all HCW; (4) the antibody level was not tested in exact time in relation with known COVID-19 (Higgins Victoria et al., 2021) (Menegale et al., 2023) (Bruxvoort et al., 2021); and, (5) interindividual variation among HCW (Higgins Victoria et al., 2021). None of the HCW had severe COVID-19 in this study. Neutralizing antibodies correlate positively with age, male sex, and severity of the disease. If we compare the antibody level of HCW with COVID-19 with that of severe COVID-19, we could clarify the association between severity of COVID-19 and antibody level (*Antibody Responses in COVID-19: A Review*, n.d.).

Ninety percent of HCW were in normal weight group and overweight group, 40% and 50% respectively. The basal antibody level was lowest in underweight group and highest in overweight group. On 'Day 70', the antibody level increased twofold in all groups. The highest level was recorded in normal weight group; it was followed by overweight group. Therefore, it confirmed the report by Lombardi et al 'BMI was positively related with antibody level following vaccination and infection' (Pyar et al., 2022) (Lombardi et al., 2021).

However, HCW in obese group had lower antibody level both basal value and 'Day 70' antibody value than overweight group in this study. All HCW in obese group had comorbid diseases; therefore, having associated comorbid diseases would be the reason for low antibody response. Nonetheless, it supported previous reports; obese individual had decrease antibody positivity (Ward et al., 2022) (Malavazos et al., 2021) (Nam et al., 2022). Antibody response in higher BMI group was found to be different between male and female. If men had higher BMI, they had lower titers of SARS-CoV-2 spike antibodies (Yamamoto et al., 2022) (Kara et al., 2022). In this study, male to female ration was equal proportion in obese group. Therefore, further study with larger sample size is needed for this controversial issue.

LIMITATION OF THE STUDY

Because of low resource setting, there were several limitations. The sample size is not large; future larger studies are required to detect factors influencing anti-Spike antibody level like age , sex, BMI, comorbid diseases etc. Moreover, serial estimation of anti-Spike antibody level after vaccination would be helpful to determine exact timing of peak level as well as the lowest level; it would be useful for recommendation of the best timing for subsequent COVID-19 vaccination particularly for risks group even in 2024. In addition, the study should also include both cellular and humoral responses as both are important for immunity. IgG concentrations should be done for immunological protection from SARS-CoV-2 variant infection.

CONCLUSION

It reflected the disease burden of COVID-19 among HCW. It indicated the immune status to SARS-CoV-2 virus in HCW working in public hospital. All HCW had good immunity to SARS-CoV-2 in January 2024. Anti-Spike antibody level became double on 'Day 70' after vaccine. One dose of (Comirnaty) COVID-19 mRNA Vaccine (nucleoside modified) tozinameran was 100% effective in promoting anti-Spike antibody. The antibody response was relatively higher in age under 40 years, female, those with current COVID-19 symptoms, those with normal weight and overweight group, and those without comorbid diseases. Antibody response was not related with history of COVID-19 in past 6 months to 1 year; therefore, they should not have false sense of security. Obese group had the lowest antibody response; high risk group for COVID-19.

RECOMMENDATION

Serial estimation of antibody level should be done. Low antibody response group such as age over 40 years, male, comorbid diseases and obese should adhere to personal protective measures and vaccination.

ACKNOWLEDGEMENTS

The authors would like to thank all the HCW for participating in this study. The authors also acknowledged Prof Ko Ko Lwin, Prof Kyaw Zay Ya, Prof Myint Zaw and Professor Thet Naing for administrative support, and Professor Tin Moe Mya for laboratory support.

Declaration of conflict of interest

The authors declared no potential conflicts of interests with respect to authorship and publication of this article.

Ethical approval

This study was approved by Hospital Research and Ethic Committee from Defence Services General Hospital (1000-Bedded) Mingaladon, Myanmar. Informed consent was also taken from each HCW.

Funding

The authors received no financial support for research and publication of this article.

REFERENCES

I. Alejo, J. L., Mitchell, J., Chang, A., Chiang, T. P. Y., Massie, A. B., Segev, D. L., & Makary, M. A. (2022). Prevalence and Durability of SARS-CoV-2 Antibodies Among Unvaccinated US Adults by History of COVID-19. *JAMA*, *327*(11), 1085–1087. https://doi.org/10.1001/jama.2022.1393

II. Althoff, K. N., Schlueter, D. J., Anton-Culver, H., Cherry, J., Denny, J. C., Thomsen, I., Karlson, E. W., Havers, F. P., Cicek, M. S., Thibodeau, S. N., Pinto, L. A., Lowy, D., Malin, B. A., Ohno-Machado, L., Williams, C., Goldstein, D., Kouame, A., Ramirez, A., Roman, A., … on behalf of the All of Us Research Program. (2022). Antibodies to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in All of Us Research Program Participants, 2 January to 18 March 2020. *Clinical Infectious Diseases*, *74*(4), 584–590. https://doi.org/10.1093/cid/ciab519

III. Anichini, G., Gandolfo, C., Terrosi, C., Fabrizi, S., Miceli, G., Gori Savellini, G., Prathyumnan, S., Franchi, F., & Cusi, M. G. (2021). Antibody response to SARS-CoV-2 in infected patients with different clinical outcome. *Journal of Medical Virology*, *93*. https://doi.org/10.1002/jmv.26789

IV. *Antibody Responses in COVID-19: A Review*. (n.d.).

V. Benkeser, D., Montefiori, D. C., McDermott, A. B., Fong, Y., Janes, H. E., Deng, W., Zhou, H., Houchens, C. R., Martins, K., Jayashankar, L., Castellino, F., Flach, B., Lin, B. C., O'Connell, S., McDanal, C., Eaton, A., Sarzotti-Kelsoe, M., Lu, Y., Yu, C., … United States Government (USG)/CoVPN Biostatistics Teams. (n.d.). Comparing antibody assays as correlates of protection against COVID-19 in the COVE mRNA-1273 vaccine efficacy trial. *Science Translational Medicine*, *15*(692), eade9078. https://doi.org/10.1126/scitranslmed.ade9078

VI. Berry, J. D., Jones, S., Drebot, M. A., Andonov, A., Sabara, M., Yuan, X. Y., Weingartl, H., Fernando, L., Marszal, P., Gren, J., Nicolas, B., Andonova, M., Ranada, F., Gubbins, M. J., Ball, T. B., Kitching, P., Li, Y., Kabani, A., & Plummer, F. (2004). Development and characterisation of neutralising monoclonal antibody to the SARS-coronavirus. *Journal of Virological Methods*, *120*(1), 87–96. https://doi.org/10.1016/j.jviromet.2004.04.009

VII. Bruxvoort, K. J., Sy, L. S., Qian, L., Ackerson, B. K., Luo, Y., Lee, G. S., Tian, Y., Florea, A., Aragones, M., Tubert, J. E., Takhar, H. S., Ku, J. H., Paila, Y. D., Talarico, C. A., & Tseng, H. F. (2021). Effectiveness of mRNA-1273 against delta, mu, and other emerging variants of SARS-CoV-2: Test negative case-control study. *BMJ*, *375*, e068848. https://doi.org/10.1136/bmj-2021-068848

VIII. Cheetham, N. J., Kibble, M., Wong, A., Silverwood, R. J., Knuppel, A., Williams, D. M., Hamilton, O. K., Lee, P. H., Bridger Staatz, C., Di Gessa, G., Zhu, J., Katikireddi, S. V., Ploubidis, G. B., Thompson, E. J., Bowyer, R. C., Zhang, X., Abbasian, G., Garcia, M. P., Hart, D., … Steves, C. J. (2023). Antibody levels following vaccination against SARS-CoV-2: Associations with post-vaccination infection and risk factors in two UK longitudinal studies. *eLife*, *12*, e80428. https://doi.org/10.7554/eLife.80428

IX. Chi, W.-Y., Li, Y.-D., Huang, H.-C., Chan, T. E. H., Chow, S.-Y., Su, J.-H., Ferrall, L., Hung, C.-F., & Wu, T.-C. (2022). COVID-19 vaccine update: Vaccine effectiveness, SARS-CoV-2 variants, boosters, adverse effects, and immune correlates of protection. *Journal of Biomedical Science*, *29*(1), 82. https://doi.org/10.1186/s12929-022-00853-8

X. de Assis, R. R., Jain, A., Nakajima, R., Jasinskas, A., Felgner, J., Obiero, J. M., Adenaiye, O., Tai, S., Hong, F., Norris, P. J., Stone, M., Simmons, G., Bagri, A., Schreiber, M., Buser, A., Holbro, A., Battegay, M., Hosimer, P., Noesen, C., … Khan, S. (2020). Analysis of SARS-CoV-2 Antibodies in COVID-19 Convalescent Blood using a Coronavirus Antigen Microarray. In *bioRxiv: The preprint server for biology* (p. 2020.04.15.043364). https://doi.org/10.1101/2020.04.15.043364

XI. Gardner, B. J., & Kilpatrick, A. M. (2024). Predicting Vaccine Effectiveness for Hospitalization and Symptomatic Disease for Novel SARS-CoV-2 Variants Using Neutralizing Antibody Titers. *Viruses*, *16*(3). https://doi.org/10.3390/v16030479

XII. Hajissa, K., Mussa, A., Karobari, M. I., Abbas, M. A., Ibrahim, I. K., Assiry, A. A., Iqbal, A., Alhumaid, S., Mutair, A. A., Rabaan, A. A., Messina, P., & Scardina, G. A. (2022). The SARS-CoV-2 Antibodies, Their Diagnostic Utility, and Their Potential for Vaccine Development. *Vaccines*, *10*(8). https://doi.org/10.3390/vaccines10081346

XIII. Haq, Md. A., Roy, A. K., Ahmed, R., Kuddusi, R. U., Sinha, M., Hossain, Md. S., Vandenent, M., Islam, M. Z., Zaman, R. U., Kibria, Md. G., Razzaque, A., Raqib, R., & Sarker, P. (2024). Antibody longevity and waning following COVID-19 vaccination in a 1-year longitudinal cohort in Bangladesh. *Scientific Reports*, *14*(1), 11467. https://doi.org/10.1038/s41598-024-61922-6

XIV. Higgins Victoria, Fabros Anselmo, & Kulasingam Vathany. (2021). Quantitative Measurement of Anti-SARS-CoV-2 Antibodies: Analytical and Clinical Evaluation. *Journal of Clinical Microbiology*, *59*(4), 10.1128/jcm.03149-20. https://doi.org/10.1128/jcm.03149-20

XV. Hogan, A. B., Doohan, P., Wu, S. L., Mesa, D. O., Toor, J., Watson, O. J., Winskill, P., Charles, G., Barnsley, G., Riley, E. M., Khoury, D. S., Ferguson, N. M., & Ghani, A. C. (2023). Estimating long-term vaccine effectiveness against SARS-CoV-2 variants: A model-based approach. *Nature Communications*, *14*(1), 4325. https://doi.org/10.1038/s41467-023-39736-3

XVI. Hwang, Y.-C., Lu, R.-M., Su, S.-C., Chiang, P.-Y., Ko, S.-H., Ke, F.-Y., Liang, K.-H., Hsieh, T.-Y., & Wu, H.-C. (2022). Monoclonal antibodies for COVID-19 therapy and SARS-CoV-2 detection. *Journal of Biomedical Science*, *29*(1), 1. https://doi.org/10.1186/s12929-021-00784-w

XVII. Kara, Z., Akçin, R., Demir, A. N., Dinç, H. Ö., Taşkın, H. E., Kocazeybek, B., & Yumuk, V. D. (2022). Antibody Response to SARS-CoV-2 Vaccines in People with Severe Obesity. *Obesity Surgery*, *32*(9), 2987–2993. https://doi.org/10.1007/s11695-022-06181-y

XVIII. Karamese, M., & Tutuncu, E. E. (2022). The effectiveness of inactivated SARS-CoV-2 vaccine (CoronaVac) on antibody response in participants aged 65 years and older. *Journal of Medical Virology*, *94*(1), 173–177. https://doi.org/10.1002/jmv.27289

XIX. Kim, J. S., Sun, Y., Balte, P., Cushman, M., Boyle, R., Tracy, R. P., Styer, L. M., Bell, T. D., Anderson, M. R., Allen, N. B., Schreiner, P. J., Bowler, R. P., Schwartz, D. A., Lee, J. S., Xanthakis, V., Doyle, M. F., Regan, E. A., Make, B. J., Kanaya, A. M., … Oelsner, E. C. (2024). Demographic and Clinical Factors Associated With SARS-CoV-2 Spike 1 Antibody Response Among Vaccinated US Adults: The C4R Study. *Nature Communications*, *15*(1), 1492. https://doi.org/10.1038/s41467-024-45468-9

XX. Li, D., Sempowski, G. D., Saunders, K. O., Acharya, P., & Haynes, B. F. (2022). SARS-CoV-2 Neutralizing Antibodies for COVID-19 Prevention and Treatment. In *Annual Review of Medicine*, (Vol. 73, Issue Volume 73, 2022, pp. 1–16). Annual Reviews,.

XXI. Lim, K., Nishide, G., Sajidah, E. S., Yamano, T., Qiu, Y., Yoshida, T., Kobayashi, A., Hazawa, M., Ando, T., Hanayama, R., & Wong, R. W. (2023). Nanoscopic Assessment of Anti-SARS-CoV-2 Spike Neutralizing Antibody Using High-Speed AFM. *Nano Letters*, *23*(2), 619–628. https://doi.org/10.1021/acs.nanolett.2c04270

XXII. Lombardi, A., Consonni, D., Oggioni, M., Bono, P., Uceda Renteria, S., Piatti, A., Pesatori, A. C., Castaldi, S., Muscatello, A., Riboldi, L., Ceriotti, F., Bandera, A., & Gori, A. (2021). SARS-CoV-2 anti-spike antibody titres after vaccination with BNT162b2 in naïve and previously infected individuals. *Journal of Infection and Public Health*, *14*(8), 1120–1122. https://doi.org/10.1016/j.jiph.2021.07.005

XXIII. Malavazos, A. E., Basilico, S., Iacobellis, G., Milani, V., Cardani, R., Boniardi, F., Dubini, C., Prandoni, I., Capitanio, G., Renna, L. V., Boveri, S., Carrara, M., Spuria, G., Cuppone, T., D'acquisto, A., Carpinelli, L., Sacchi, M., Morricone, L., Secchi, F., … Corsi Romanelli, M. M. (2021). Antibody responses to BNT162b2 mRNA vaccine: Infection-naïve individuals with abdominal obesity warrant attention. *medRxiv*, 2021.09.10.21262710. https://doi.org/10.1101/2021.09.10.21262710

XXIV. Menegale, F., Manica, M., Zardini, A., Guzzetta, G., Marziano, V., d'Andrea, V., Trentini, F., Ajelli, M., Poletti, P., & Merler, S. (2023). Evaluation of Waning of SARS-CoV-2 Vaccine–Induced Immunity: A Systematic Review and Meta-analysis. *JAMA Network Open*, *6*(5), e2310650–e2310650. https://doi.org/10.1001/jamanetworkopen.2023.10650

XXV. Müller, L., Andrée, M., Moskorz, W., Drexler, I., Walotka, L., Grothmann, R., Ptok, J., Hillebrandt, J., Ritchie, A., Rabl, D., Ostermann, P. N., Robitzsch, R., Hauka, S., Walker, A., Menne, C., Grutza, R., Timm, J., Adams, O., & Schaal, H. (2021). Age-dependent immune response to the Biontech/Pfizer BNT162b2 COVID-19 vaccination. *medRxiv*, 2021.03.03.21251066. https://doi.org/10.1101/2021.03.03.21251066

XXVI. Nam, S. Y., Jeon, S. W., Lee, H. S., Lim, H. J., Lee, D. W., & Yoo, S. S. (2022). Demographic and Clinical Factors Associated With Anti–SARS-CoV-2 Antibody Levels After 2 BNT162b2 mRNA Vaccine Doses. *JAMA Network Open*, *5*(5), e2212996–e2212996. https://doi.org/10.1001/jamanetworkopen.2022.12996

XXVII. Niyas, V. K. M., & Arjun, R. (2021). Response to letter re Breakthrough COVID-19 infections among health care workers after two doses of ChAdOx1 nCoV-19 vaccine. *QJM : Monthly Journal of the Association of Physicians*. https://doi.org/10.1093/qjmed/hcab204

XXVIII. Ortega, N., Ribes, M., Vidal, M., Rubio, R., Aguilar, R., Williams, S., Barrios, D., Alonso, S., Hernández-Luis, P., Mitchell, R. A., Jairoce, C., Cruz, A., Jimenez, A., Santano, R., Méndez, S., Lamoglia, M., Rosell, N., Llupià, A., Puyol, L., … Dobaño, C. (2021). Seven-month kinetics of SARS-CoV-2

antibodies and role of pre-existing antibodies to human coronaviruses. *Nature Communications*, *12*(1), 4740. https://doi.org/10.1038/s41467-021-24979-9

XXIX. Pyar, K. P. (2022). Breakthrough infections due to SARS-CoV-2 Wild type, the Delta variant and the Omicron variant in early fourth wave of epidemics in Myanmar. *International Journal Of Medical Science And Clinical Research Studies*, *02*(02). https://doi.org/10.47191/ijmscrs/v2-i2-10

XXX. Pyar, K. P., Hla, S., Maung, K., Thu, A., Aung, H., Wynn, T., Wah, S., Kyaw, M., Aung, Z., Min, S., Oo, K., Tun, T., Aung, Z. N. H., Hlaing, S. W., Aung, S., Lin, M., & Kyaw, A. (2022). *Anti-Spike Antibody Responses to Covid-19 Vaccine 3 Doses in Health Care Workers Working in Acute Care Hospital in Myanmar*. *7*, 2022.

XXXI. Pyar, K. P., Hla, S., Min, A., Wunn, D., Aung, Z. N., Lin, M., Win, T., Aung, L., Kyaw, A., Ya, K., Tun, T., Kyaw, M., Oo, Z., Aung, Z., Lin, T., & Htun, S. (2021). Breakthrough Infection among Fully Vaccinated Physicians Working in COVID-19 Treatment Centers; Prevalence, Presenting Symptoms, Co-Morbidities and Outcome in the Third Wave of Epidemics in Myanmar. *Journal of Biomedical Research & Environmental Sciences*, *2*, 721–730. https://doi.org/10.37871/jbres1303

XXXII. Pyar, K. P., Hla, S., Thu, K., Lwin, Y., Shwe, W., Maung, L., Hein, Y., Aung, L., Thant, M., maung maung, M., Zaw, M., Lin, M., Phone, S., Kyaw, A., Aung, Z., Kyaw, M., Oo, Z., Oo, K., Ko, M., & Aung, Z. N. H. (2023). *Anti-Spike Antibody Level Following COVID-19 Vaccine 4 Doses in Patients on Maintenance Hemodialysis in Government Hospital, Myanmar*. *5*, 519–527. https://doi.org/10.32474/JCCM.2023.05.000204

XXXIII. Rangsrisaeneepitak, V., Porntharukchareon, T., Dechates, B., Sirisreetreerux, S., & Tawinprai, K. (2022). Antibody levels in people with diabetes after one dose of the ChAdOx1 nCoV-19 (AZD1222) vaccine. *Diabetology International*. https://doi.org/10.1007/s13340-022-00582-1

XXXIV. Rodda, L. B., Morawski, P. A., Pruner, K. B., Fahning, M. L., Howard, C. A., Franko, N., Logue, J., Eggenberger, J., Stokes, C., Golez, I., Hale, M., Gale, M., Chu, H. Y., Campbell, D. J., & Pepper, M. (2022). Imprinted SARS-CoV-2-specific memory lymphocytes define hybrid immunity. *Cell*, *185*(9), 1588-1601.e14. https://doi.org/10.1016/j.cell.2022.03.018

XXXV. Sharma, P., Mishra, S., Basu, S., Tanwar, N., & Kumar, R. (2021). Breakthrough infection with SARS-CoV-2 and its predictors among healthcare workers in a medical college and hospital complex in Delhi, India. *medRxiv*, 2021.06.07.21258447. https://doi.org/10.1101/2021.06.07.21258447

XXXVI. Sughayer, M. A., Souan, L., Abu Alhowr, M. M., Al Rimawi, D., Siag, M., Albadr, S., Owdeh, M., & Al Atrash, T. (2022). Comparison of the effectiveness and duration of anti-RBD SARS-CoV-2 IgG antibody response between different types of vaccines: Implications for vaccine strategies. *Vaccine*, *40*(20), 2841–2847. https://doi.org/10.1016/j.vaccine.2022.03.069

XXXVII. Sumpaico-Tanchanco, L. B. C., Sy, J. C. Y., Dy, A. B. C., Levantino, M., Amit, A. M. L., Wong, J., Angeles, K., & Vergara, J. P. C. (2022). The prevalence of SARS-CoV-2 antibodies within the community of a private tertiary university in the Philippines: A serial cross sectional study. *PloS One*, *17*(12), e0268145. https://doi.org/10.1371/journal.pone.0268145

XXXVIII. Tannous, J., Pan, A. P., Potter, T., Bako, A. T., Dlouhy, K., Drews, A., Sostman, H. D., & Vahidy, F. S. (2023). Real-world effectiveness of COVID-19 vaccines and anti-SARS-CoV-2 monoclonal antibodies against postacute sequelae of SARS-CoV-2: Analysis of a COVID-19 observational registry for a diverse US metropolitan population. *BMJ Open*, *13*(4), e067611. https://doi.org/10.1136/bmjopen-2022-067611

XXXIX. Torres, J. L., Ozorowski, G., Andreano, E., Liu, H., Copps, J., Piccini, G., Donnici, L., Conti, M., Planchais, C., Planas, D., Manganaro, N., Pantano, E., Paciello, I., Pileri, P., Bruel, T., Montomoli, E., Mouquet, H., Schwartz, O., Sala, C., … Ward, A. B. (2022). Structural insights of a highly potent pan-neutralizing SARS-CoV-2 human monoclonal antibody. *Proceedings of the National Academy of Sciences*, *119*(20), e2120976119. https://doi.org/10.1073/pnas.2120976119

XL. Tyagi, K., Ghosh, A., Nair, D., Dutta, K., Singh Bhandari, P., Ahmed Ansari, I., & Misra, A. (2021). Breakthrough COVID19 infections after vaccinations in healthcare and other workers in a chronic care medical facility in New Delhi, India. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *15*(3), 1007–1008. https://doi.org/10.1016/j.dsx.2021.05.001

XLI. Wang, L., Li, J., Gao, Y., Li, R., Zhang, J., Su, D., Wang, T., Yang, G., & Wang, X. (2019). Association

between coronary dominance and acute inferior myocardial infarction: A matched, case-control study. *BMC Cardiovascular Disorders*, *19*(1), 35. https://doi.org/10.1186/s12872-019-1007-5

XLII. Ward, H., Whitaker, M., Flower, B., Tang, S. N., Atchison, C., Darzi, A., Donnelly, C. A., Cann, A., Diggle, P. J., Ashby, D., Riley, S., Barclay, W. S., Elliott, P., & Cooke, G. S. (2022). Population antibody responses following COVID-19 vaccination in 212,102 individuals. *Nature Communications*, *13*(1), 907. https://doi.org/10.1038/s41467-022-28527-x

XLIII. Yamamoto, S., Mizoue, T., Tanaka, A., Oshiro, Y., Inamura, N., Konishi, M., Ozeki, M., Miyo, K., Sugiura, W., Sugiyama, H., & Ohmagari, N. (2022). Sex-associated differences between BMI and SARS-CoV-2 antibody titers following the BNT162b2 vaccine. *Obesity (Silver Spring, Md.)*, *30*(5), 999–1003. https://doi.org/10.1002/oby.23417

XLIV. Zeng, B., Gao, L., Zhou, Q., Yu, K., & Sun, F. (2022). Effectiveness of COVID-19 vaccines against SARS-CoV-2 variants of concern: A systematic review and meta-analysis. *BMC Medicine*, *20*(1), 200. https://doi.org/10.1186/s12916-022-02397-y

Table (1) clinical characteristics of HCW (n=99)

Clinical Characteristics		No. of HCW	Percent
Age Group	< 40	68	68.7 %
	>= 40	31	31.3%
Age (mean)	34.87±9.02 years	Minimum 20 year	Maximum 61 year
Gender	Male	90	90.9%
	Female	9	9.1%
Comorbid Status	Presence of Comorbid disease	13 DM - 3 Obesity + Hypertension- 2 Hypertension - 5 Bronchial asthma- 1 Hypothyroid- 1 Mitral Stenosis- 1	13.1%
	No Comorbid disease	86	86.9%
Last Vaccination 3-6 months ago	Vaccination done	79	79.8%
	Vaccination not done	20	20.2%
Last Vaccination within past 3 months	Vaccination done	19	19.2%
	Vaccination not done	80	80.8%
Previous COVID-19 6 months - 1 year	Yes	73 Clinical Covid symptoms + = 48(48.5%) RDT+ COVID infection = 17 (17.2%)	73.7%

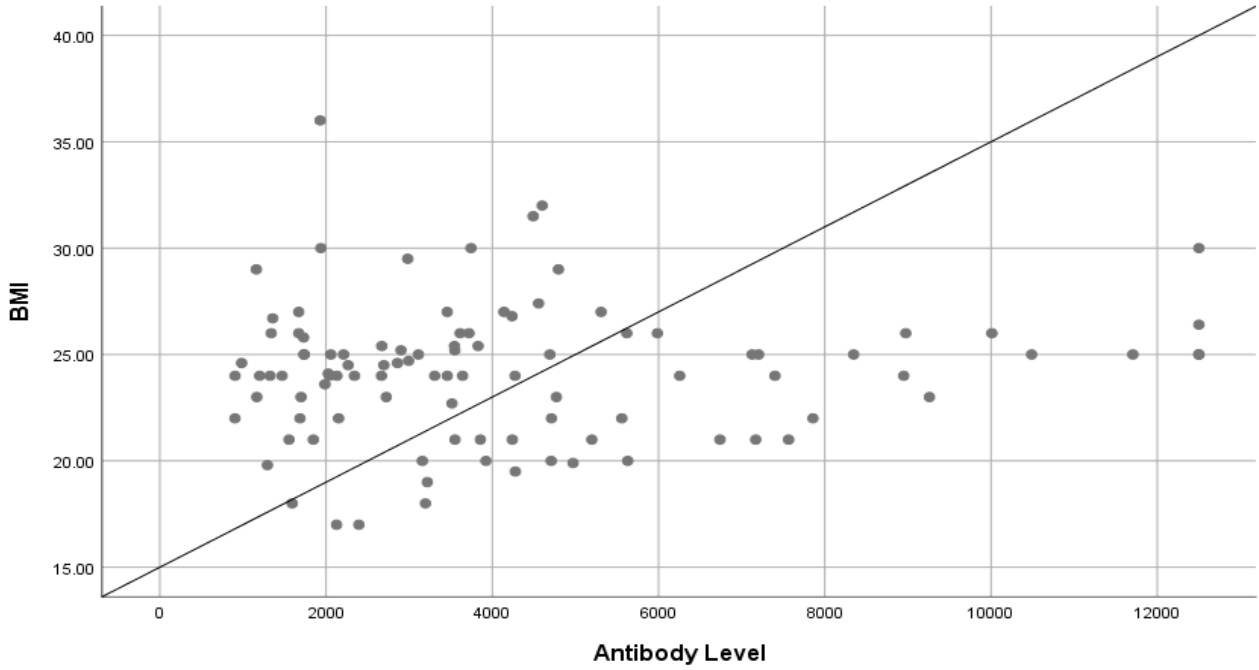
		PCR + COVID infection = 8 (8.1%)	
	No	26	26.3%
Covid Symptoms at the time of vaccination	Yes	8	8.1%
	No	91	91.9%
BMI (mean) kg/m^2	24.19 ± 3.20	minimum - 17	Maximum - 36
BMI Group kg/m^2	<18.5	4	4.0 %
	18.5 -24.9	51	51.5%
	25 - 29.9	38	38.4%
	≥ 30	6	6.1%
Basal Mean COVID Antibody level	4195.04 ± 2898.20	Minimum - 904	Maximum - 12500
'Day 70' Mean COVID Antibody level	9115.31± 3518.89	Minimum - 2013	Maximum -12500

Table (2) Association between clinical characteristics and baseline COVID -19 antibody level (n=99)

Clinical Characteristics		Mean antibody level ± SD	Minimum	Maximum	F	P value
Age Group (yr)	< 40	3538.85 ± 2102.61	904	12500	12.43	0.001*
	>= 40	5634.42 ± 3801.08	1161	12500		
Gender	Male	3878.04 ± 2334.64	904	12500	13.33	<0.001*
	Female	7365 ± 5460.97	1358	12500		
Comorbid Status	Presence of Comorbid disease	5038.38 ±4301.14	1161	12500	1.27	0.26
	No Comorbid disease	4067.56±2635.76	904	12500		
COVID-19 6 months – 1 year ago	Yes	4059.10 ± 2845.44	904	12500	0.61	0.44
	No	4576.73 ± 3066.46	1161	12500		

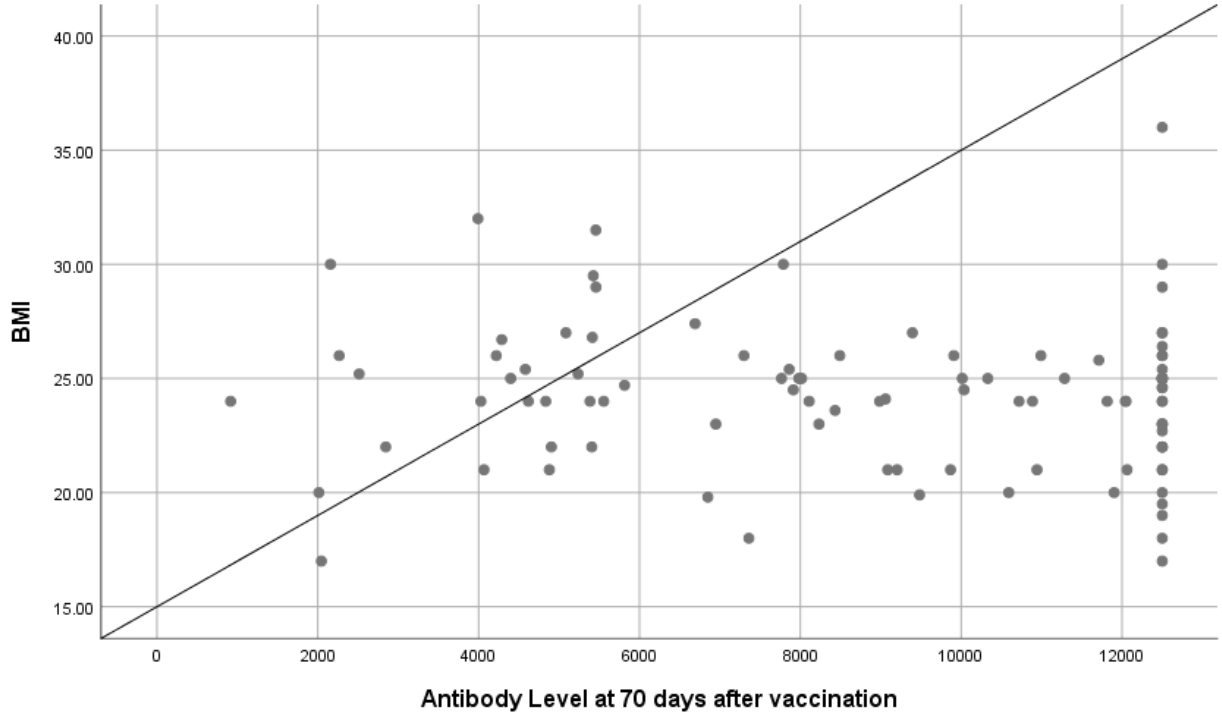
Covid Symptoms at the time of vaccination	Yes	5066.88 ± 4004.35	1470	12500	0.79	0.38
	No	4118.40 ± 2797.42	904	12500		
BMI Group (kg/m^2)	<18.5	2327.00±668.00	1592	3195	2.388	0.74
	18.5 -24.9	3648.41±2180.46	904	9259		
	25 - 29.9	5019.26±3485.20	1161	12500		
	≥ 30	4866.67±3923.10	1929	12500		

***P value with comparing means by ANOVA**



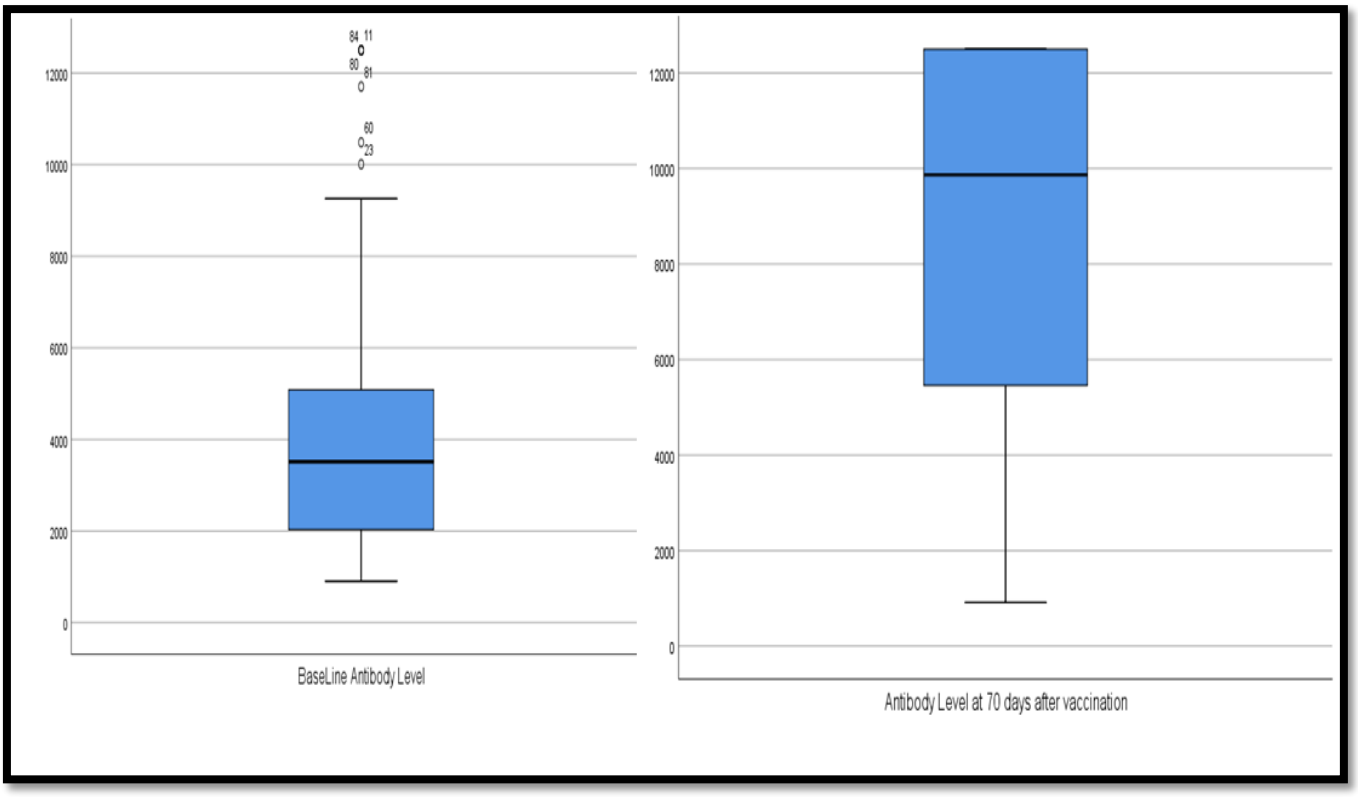
R	R ^{2}	t	P value
0.094	0.009	-0.93	0.36

Figure (1) Correlation between BMI status and baseline COVID-19 antibody level (n=99)



R	R^2	t	P value
0.098	0.10	-0.97	0.33

Figure (2) Correlation between BMI status and COVID-19 antibody level at 'Day 70' (n=99)



Figure(3) Comparison of COVID antibodies level between baseline and 70 days after vaccination (n=99)

Table (3) Comparison of COVID antibodies level between baseline and 70 days after vaccination (n=99)

COVID Antibody Level	**Mean ± SD**	**Minimum**	**Maximum**	
Basal level	4195.04 ± 2898.20	904	12500	
Day 70 level	9115.31± 3518.89	2013	12500	
Mean Difference	**95% CI**	**t**	**df**	**P value**
4861.82±4090.38	4046.02 - 5677.64	11.83	98	**<0.001**

P value by paired sample t-test

Table (4) Association between clinical characteristics and COVID -19 antibody level at 70 days after vaccination (n=99)

Clinical Characteristics		**Mean antibody level ± SD**	**Minimum**	**Maximum**	**F**	**P value**
Age Group (yr)	< 40	9564.37±3265.608	915	12500	4.898	0.029*
	>= 40	7864.55±4098.874	2044	12500		
Gender	Male	8894.85±3487.904	915	12500	1.434	0.234
	Female	10404.67±4725.860	4287	12500		
Comorbid Status	Presence of Comorbid disease	8461.46±3854.047	2157	12500	0.371	0.544
	No Comorbid disease	9118.37±3592.362	915	12500		
COVID-19 6 months – 1 year ago	Yes	8656.58±3581.47	915	12500	3.06	0.08
	No	10086.46±3562.65	2013	12500		
Covid Symptoms at the time of vaccination	Yes	9225.25±3426.82	4028	12500	0.25	0.87
	No	9015.13±3647.71	915	12500		
BMI Group (kg/m^2)	<18.5	8601.00±4997.95	2044	12500	0.5	0.68
	18.5 -24.9	9225.03±3416.99	915	12500		
	25 - 29.9	8924.21±3423.11	2266	12500		
	≥ 30	7398.67±4360.27	2157	12500		

***P value with comparing means by ANOVA**

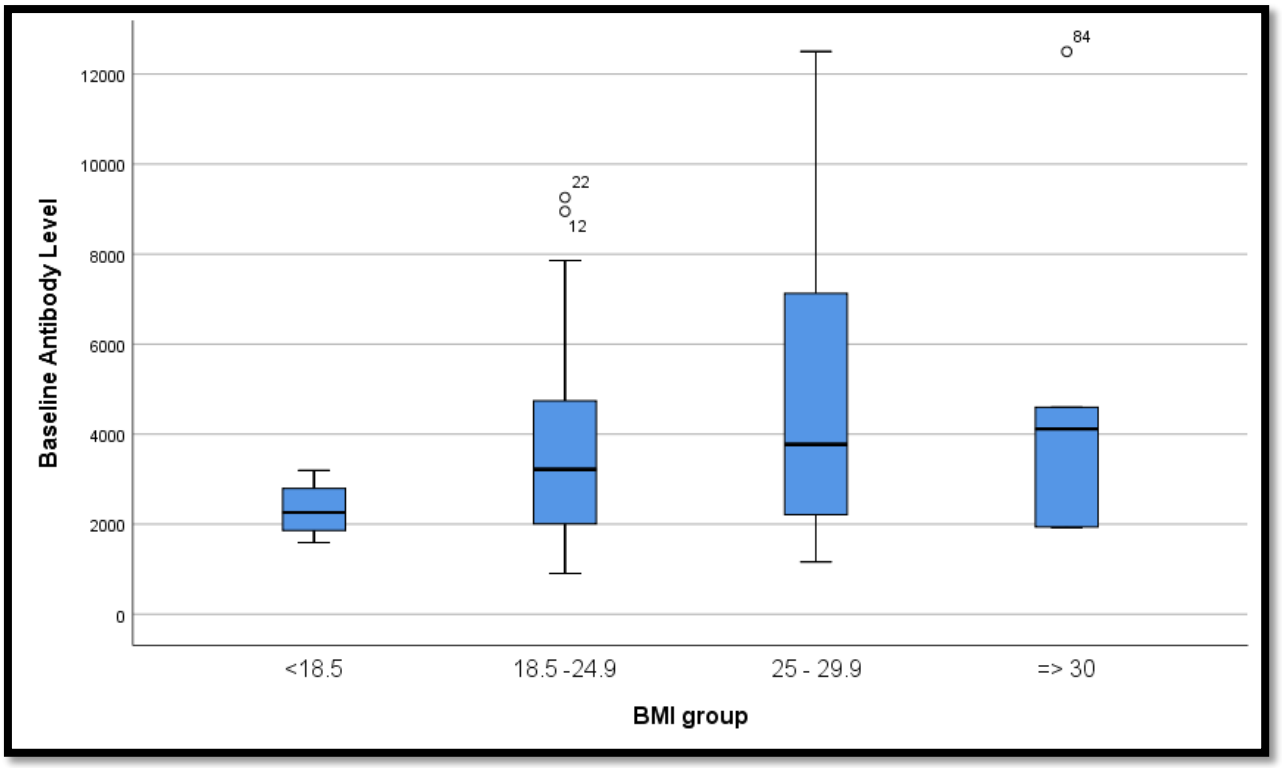


Figure (4) Comparison of mean baseline COVID-19 antibody levels between BMI group (n=99)

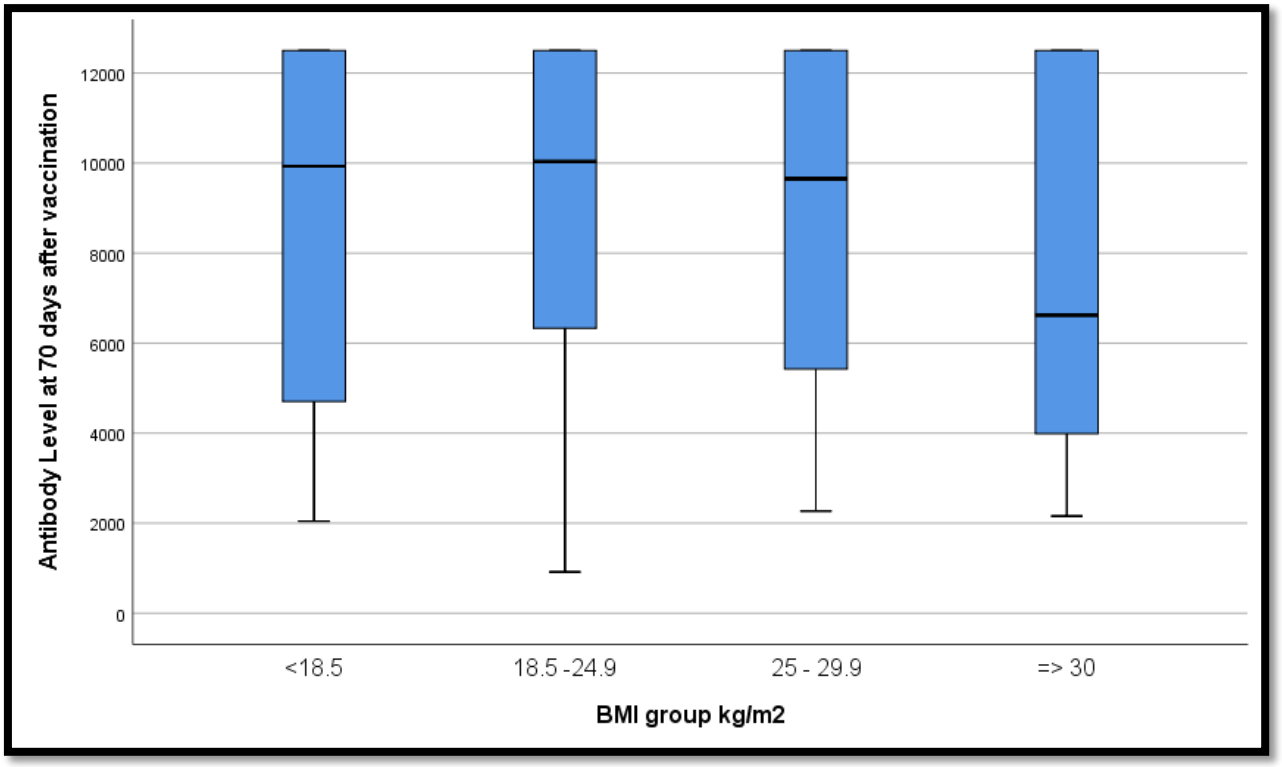


Figure (5) Comparison of mean COVID-19 antibody levels at 70 days after vaccination between BMI group (n=99)