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Effectiveness of Covid-19 Vaccines in Immunity and Disease Protection Among Healthcare Practitioners: A Retrospective Study

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Abstract:
The World Health Organization believes that vaccination is still the most cost-effective medical intervention against COVID-19. This retrospective experimental study conducted among the 819 healthcare practitioners, who were purposively chosen, sought to find out the effectiveness of COVID-19 vaccines in immunity and disease protection. The participants' level of immunity was based on the results of the neutralizing antibody, while the degree of protection was determined by the evaluation of the participant's hospitalization records after they received two doses of vaccine and after the booster shot. The participants who received the 1st and 2nd doses of Inactivated Vero Cell vaccine did not develop immunity, while those who received Viral S Protein Recombinant vaccine developed moderate immunity. After the booster shot, both cohorts had high immunity. Participants who received the 1st and 2nd doses of Inactivated Vero Cell vaccine were not protected from the infection, while those who received Viral S Protein Recombinant vaccine were highly protected. After the booster shot, both cohorts were highly protected. The findings show that the Inactivated Vero Cell and Viral S Protein Recombinant vaccines significantly differ in providing immunity and protection. Moderating variables such as risk classification, living arrangement, and comorbidities has a significant effect on the level of immunity and degree of protection. Considering the results of the study, it could be concluded that Astra Zeneca COVID-19 vaccine was effective in terms of providing immunity and protection among healthcare workers while Sinovac vaccine was not effective in terms of providing immunity nor protection among healthcare workers. Furthermore, receiving booster shots will increase the level of immunity and degree of protection. It is also recommended that Astra Zeneca be given to the people over Sinovac vaccine. In addition, it is highly recommended to use Pfizer vaccine, if available as booster shot regardless of the brand of vaccine given during the first and second vaccination.

Keywords: COVID-19, COVID Vaccines, Level of Immunity, Degree of Protection

1. BACKGROUND

The emergence of COVID-19 in late 2019 triggered an unprecedented global health crisis, prompting the accelerated development and deployment of vaccines worldwide. By 2021, vaccination programs were in full swing across various countries, with healthcare practitioners (HCPs) being prioritized due to their heightened risk of exposure. Amid the pandemic, monitoring vaccine effectiveness in real-world settings, especially among frontliners, became essential to guide policy and strengthen public trust.

Despite the widespread rollout of COVID-19 vaccines, questions remained regarding the extent and duration of protection, particularly in diverse populations such as healthcare workers who were repeatedly exposed to the virus. Limited longitudinal and localized data on vaccine-induced immunity and breakthrough infections among HCPs led to hesitations, misinformation, and uncertainties around booster doses and long-term protection. These knowledge gaps hindered the refinement of vaccination strategies during the critical early phases of the pandemic response.

This retrospective study aimed to evaluate the effectiveness of COVID-19 vaccines in providing immunity and disease protection among healthcare practitioners. Specifically, it assessed the incidence of breakthrough infections, severity of symptoms, and correlation with vaccine types, intervals, and booster administration over a defined period post-vaccination.

The findings of this study offer valuable insights into the real-world impact of COVID-19 vaccines on the frontline workforce. By presenting evidence on immunity outcomes and infection trends among HCPs, the study supports data-driven decisions on booster schedules, occupational health policies, and public health communication strategies. Its retrospective nature also serves as a critical documentation of the early vaccine response and its practical outcomes during the height of the pandemic.

Definition of Terms

Effectiveness refers to the level of immunity and level of protection against COVID-19.

Healthcare Practitioners includes all employees working in the hospital who are considered as front-liners. This study involved all medical, non-medical, and support personnel in the hospital.

Inactivated Vero Cell refers to a Sinovac vaccine

Immunity refers to the level of neutralizing antibodies (NAb) produced by an individual in response to a vaccination received.

Neutralizing Antibody (NAb) is a type of antibody produced in response to the vaccine that will tell if the person has developed immunity or not. A neutralizing antibody titer of higher than 10% signifies immunity.

Viral S Protein Recombinant refers to Astra Zeneca vaccine

2. METHODOLOGY

Figure 1

Conceptual Paradigm on COVID-19 Vaccine Immunity and Protection

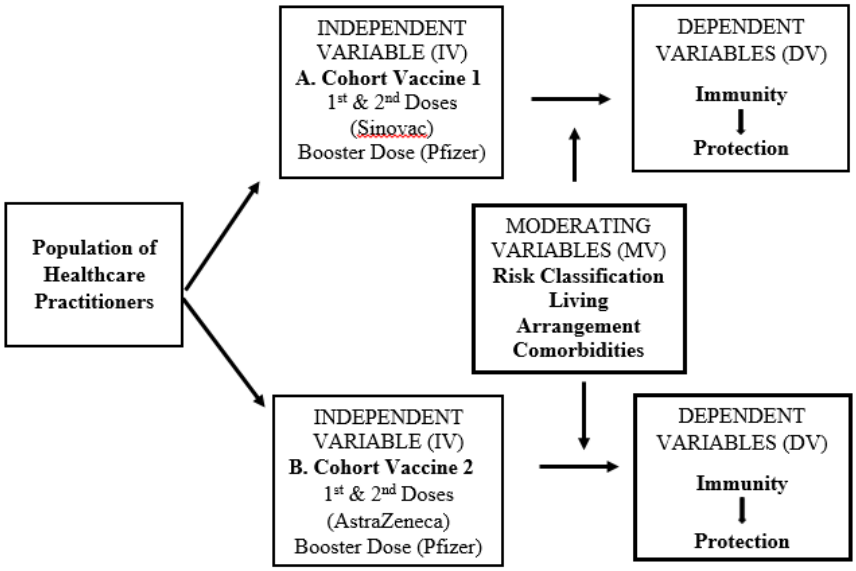
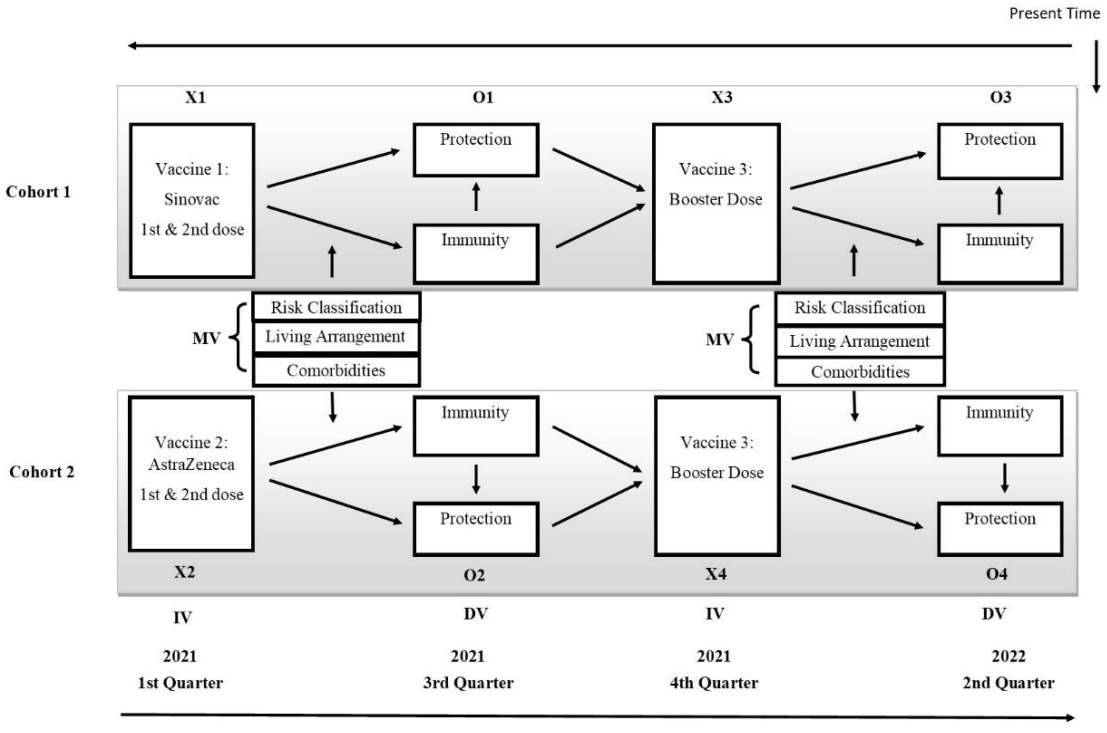


Figure 2

Retrospective Experimentation Process



The researcher employed a retrospective experimental research design in conducting this study.The researcher used a purposive sampling technique, by means of a set of inclusion criteria to select participants from the identified population. All the 819 healthcare practitioners, who were vaccinated in the first quarter of 2021, were included initially as a research population. The researcher divided the population into 2 Cohorts: those who received 1st and 2nd doses of Sinovac vaccine were assigned to Cohort 1; and those who received 1st and 2nd doses of Viral S Protein Recombinant vaccine were assigned to Cohort 2. After which, all participants were assessed based on the inclusion criteria as follows: 1st dose vaccination must be done in March 2021; 2nd dose vaccination shall be in the month of May-June, 2021; the booster dose, shall be in December 2021; 1st neutralizing antibody testing must be conducted in July- August 2021; and the 2nd neutralizing antibody testing shall be in March-April, 2022. Participants who are not complying with the inclusion criteria were removed from the list. All the remaining participants in each cohort were included as the actual participants of the study.

RESULTS AND DESCRIPTION

Table 1

Cohorts, Frequency and Percentage of the Participants Based on Vaccine Administered

Cohort/Vaccine	Frequency	Percentage
1. Sinovac	118	46.8
2. Viral S Protein Recombinant	134	53.2
Total	252	100%

Table 1 showed that there were a total of 252 participants of the study who were divided into 2 cohorts. Cohort 1, Sinovac with 118 participants, and cohort 2, Viral S Protein Recombinant with 134 participants.

The effects of the moderating variables on the level of immunity and degree of protection were also determined in this study. After identifying the participants of the study in 2 cohorts, the demographic profile based on the moderating variables was taken as shown in the succeeding tables.

Table 2

Demographic Profile of the Participants Based on Risk Classification

Cohort 1: Sinovac		Frequency	Percent	Valid Percent	Cumulative %
Valid	Low Risk	35	29.7	29.7	29.7
	Moderate Risk	36	30.5	30.5	60.2
	High Risk	47	39.8	39.8	100.0
	Total	118	100.0	100.0	
Cohort 2: Viral S Protein Recombinant		Frequency	Percent	Valid Percent	Cumulative %
Valid	Low Risk	34	25.4	25.4	25.4
	Moderate Risk	37	27.6	27.6	53.0
	High Risk	63	47.0	47.0	100.0
	Total	134	100.0	100.0	

Table 3

Demographic Profile of the Participants Based on Living Arrangement

Cohort 1: Inactivated Vero Cell		Frequency	Percent	Valid Percent	Cumulative %
Valid	Ideal	43	36.4	36.4	36.4
	Acceptable	32	27.1	27.1	63.6
	Not Ideal	43	36.4	36.4	100.0
	Total	118	100.0	100.0	
Cohort 2: Viral S Protein Recombinant		Frequency	Percent	Valid Percent	%
Valid	Ideal	42	31.3	31.3	31.3
	Acceptable	42	31.3	31.3	62.7
	Not Ideal	50	37.3	37.3	100.0
	Total	134	100.0	100.0	

Table 4

Demographic Profile of the Participants Based on Comorbidities

		Frequency	Percent	Valid Percent	Cumulative %
Valid	None	68	57.6	57.6	57.6
	hypertension	25	21.2	21.2	78.8
	Diabetes	16	13.6	13.6	92.4
	Allergy	9	7.6	7.6	100.0
	Total	118	100.0	100.0	
		Frequency	Percent	Valid Percent	Cumulative %
Valid	None	79	59.0	59.0	59.0
	hypertension	19	14.2	14.2	73.1
	Diabetes	14	10.4	10.4	83.6
	Asthma/Allergy	22	16.4	16.4	100.0
	Total	134	100.0	100.0	

Table 5

Degree of Protection Interpretation Guide Based on COVID-19 Diagnosis

Scale	**Diagnosis**	**Interpretation**
6	Negative for COVID-19	Highly Protected
5	Asymptomatic Case	Moderately Protected
4	Mild COVID-19	Protected
3	Moderate COVID-19	Slightly Not Protected
2	Severe COVID-19	Not Protected
1	Critical COVID-19	Highly Not Protected

Status of Vaccination, Comorbidities and Living Arrangements

The researcher employed the hospital information system known as Bizbox at LUDHMC, to collect data from the source/ data base. This is a sort of electronic medical record (EMR) technology used to store patients data including their vaccination and hospitalization records and the personal information including comorbidities, living arrangements, and area of assignment. All the data from the system was verified by the researcher from the participants through interview using the COVID-19 data form.

Using the COVID-19 Form, comorbidities are grouped into four categories: (1) Hypertension with maintenance medicine, (2) Diabetes with maintenance medicine, (3) Asthma/Allergy, and (4) Other medical conditions. The living arrangement was also divided into three categories: (1) Ideal, (2) Acceptable, and (3) Not Ideal. The total living arrangement rating was obtained by adding the points of the participant in the three parameters such as transportation vehicle, home set-up, and other activities. Each parameter has three sub-class with points from 1-3. Living arrangement total rating will be interpreted using this criterion in Table 6.

Table 6

Living Arrangement Interpretation Guide

Total Rating	Living Arrangement Category
1-3	Ideal
4-6	Acceptable
7-9	Not Acceptable

Risk Classification

To find out the participants risk classification, the researcher utilized the criteria for risk classification by the Department of Health (DOH) as stipulated on the Joint Circular No. 2022-001 dated February 10, 2022 entitled “Guidelines on the Grant of One COVID-19 Allowance (OCA) to Public and Private Health care Workers (HCWs) and Non-HCWs in Health Facilities Involved in COVID-19 Response”.

Each participant was given a rating based on the three criteria: type of facility, work setting, and nature of work. The point system was used to come up with a very objective way of classifying HCWs into High Risk, Moderate Risk and Low Risk. A healthcare worker can get a maximum of 3 points for each of the three risk criteria used. The total number of points from the three (3) criteria shall be added to get the sum, which served as the healthcare workers overall risk classification. Table 3 shows the interpretation of the risk classification.

Table 7

Risk Classification Interpretation Guide

Total Points	Risk Classification
1-3	Low Risk

4-6	Moderate Risk
7-9	High Risk

Table 8

Level of Immunity Interpretation Guide Based on Neutralizing Antibody Result

% nAb	Interpretation
<10%	No antibodies, No Immunity
10%-29.9%	Low Titer, Low Immunity
≥30%-60%	Moderate Titer, Moderate Immunity
>60%-100%	High Titer, High Immunity

Using the 4-point Likert scale, the WAM will be interpreted using the interpretation guide in Table 9.

Table 9

Level of Immunity WAM Interpretation Guide

WAM	Verbal Description
1.00 - 1.75	No immunity
1.76 – 2.50	Low immunity
2.51 – 3.25	Moderate Immunity
3.26 – 4.00	High Immunity

To determine the degree of protection, weighted average mean (WAM) was used with the following interpretation criteria:

Table 10

Degree of Protection WAM Interpretation Guide

WAM	Verbal Description
5.17 – 6.00	Highly Protected
4.34 – 5.16	Moderately Protected
3.51 – 4.33	Protected
2.68 – 3.50	Slightly Not Protected
1.84 – 2.67	Not Protected
1.00 – 1.83	Highly Not Protected

To determine if there is a significant difference between cohort 1 and cohort 2 after receiving the 2 doses of vaccine and after the booster shot in terms of level of immunity and degree of protection, a t-Test for independent samples was used. The Independent Samples t-Test is a parametric test used to compare the means of two independent groups to find out if there is statistical evidence that the associated population means are significantly different.

To assess if moderating variables like risk classifications, living arrangements, and comorbidities have significant effects on the level of immunity and degree of protection, one-way ANOVA with Tukey's HSD (honestly significant difference) was used. The one-way analysis of variance (ANOVA) was used to determine whether there are any statistically significant differences between the means of three or more independent groups, just like the moderating variables in this study.

To demonstrate the correlation between the level of immunity and level of protection, the researcher had employed Spearman's Rho as statistical treatment. Spearman's Rho is a non-parametric test used to measure the strength of association between two variables, just like immunity and protection in this study. This test will find out whether level of immunity and degree of protection are correlated.

Ethical Consideration

The researcher upholds the ethical guidelines in conducting this research study. First, permission was obtained from the Ethics Research Board (ERB) of Adventist University of the Philippines before the conduct of this study. Second, a permit and approval were secured from the Ethics Research Committee (ERC) of LUDHMC. Third, a consent was taken from the participants to ensure that they understood the undertakings of the study. Participant's information shall be kept with utmost confidentiality. The researcher has been authorized by Lucena United Doctors Hospital and Medical Center to conduct this study using its available resources to obtain reliable data which are of clinical value to the hospital for the benefit of the patients. No other potential conflict of interest relevant to this study was noted.

Results and Discussion

This presents the results, interpretation, and discussion of the outcomes of study and its supporting literature. The results which are aligned to the statement of the problem are presented on tabular and graphical form.

Participants' Level of Immunity and Degree of Protection

Tables 11 and 12 show the results of the participants' level of immunity and degree of protection. The vaccine brand or cohort, total number of participants, scaled results, mean, and verbal interpretation of the mean for each variable are presented in the table.

Table 11

Participants' Level of Immunity

Vaccine Brand/ Cohort	Variables	N	No Titer (1)	Low Titer (2)	Mod Titer (3)	High Titer (4)	Mean	Verbal Interpretation
Cohort 1: Inactivated Vero Cell	Level of Immunity (After 1st and 2nd dose)	118	89	17	3	9	1.42	No Immunity

	Level of Immunity (After Booster)	118	0	2	6	110	3.92	High Immunity
Cohort 2: Viral Protein Recombinant	Level of Immunity S(After 1st and 2nd dose)	134	8	12	78	36	3.06	Moderate Immunity
	Level of Immunity (After Booster)	134	0	0	0	134	4.00	High Immunity

The level of immunity after the 1st and 2nd doses of Inactivated Vero Cell, with a mean of 1.42, indicates no immunity. It means that the healthcare workers did not develop enough antibodies against the disease. After the booster shot, the mean is 3.92, which means that the healthcare workers have high immunity. The booster shot strengthen and increase antibody production which is because of the 1st snd/ 2nd doses of vaccine. In this dstudy, immunity of the respective cohorts, is due to the 1st and2nd vaccine doses and was only improved by the booster shot, regardless what vaccine brand was used.For the Viral S Protein Recombinant vaccine, the healthcare workers' mean level of immunity after the 1st and 2nd doses is 3.06, which denotes that they have moderate immunity, and it goes higher to 4.0 after the booster shot, giving them high immunity.

According to Tregoning et al. (2021), the different brands of vaccines vary in terms of their efficacy in providing immunity. Pfizer–BioNTech has 95% efficacy for immunity (Polack et al., 2020), Viral S Protein Recombinant–the University of Oxford has 67-81% efficacy (Voysey et al., 2021), and Sinovac Biotech has 50-91% efficacy (Kim et al., 2021).

Table 12

Participants' Degree of Protection

Vaccine Brand/ Cohort	Variables	N	HP (6)	MP (5)	P (4)	SP (3)	NP (2)	HNP (1)	Mean	Verbal Interpretation
Cohort 1: Inactivated Vero Cell	Degree of Protection (After 1st and 2nd dose)	118	3	13	39	63	0	0	2.02	Not Protected
	Degree of Protection (After Booster)	118	111	7	0	0	0	0	5.94	Highly Protected
Cohort 2: Astra-Zeneca	Degree of Protection (After 1st and 2nd dose)	134	72	50	7	5	0	0	4.66	Moderately Protected
	Degree of Protection (After Booster)	134	131	3	0	0	0	0	5.97	Highly Protected

The results in Table 12 show that the participants' degree of protection after receiving the 1st and 2nd doses of Inactivated Vero Cell vaccine has a mean of 2.02, which means that they are not protected, while after a booster shot, it became highly protected with the mean of 5.94. For participants receiving the Viral S Protein Recombinant vaccine, it has a mean of 4.66 after the 1st and 2nd doses and 5.97 after the booster shot. Both results show that the participants are highly protected after the booster shot.

The efficacy of COVID-19 vaccines in terms of protection vary depending on brand. The Pfizer–BioNTech has 100% efficacy for protection (Polack et al., 2020), Viral S Protein Recombinant–the University of Oxford has 100% (Voysey et al.,2021), and Sinovac Biotech has 51-100% depending on disease manifestation (Kim et al.,2021).

Differences in the Level of Immunity and Degree of Protection within Cohort

The results in tables 13 and 14 provide answers to the question of whether there is a significant difference in the level of immunity and degree of protection of the participants after receiving the 1st and 2nd doses of vaccine, with the results after the booster shot in 2 cohorts.The mean refelected on the tables refer to the mean count of the neutralizing antibodies from all the participants count.

Table 13

Differences on the Participants' Level of Immunity within the Cohort

Variables	Cohort / Vaccine	N	Mean	SD	t value	p value	Significance Level	Interpretation
Level of Immunity (After 1st and 2nd dose)	Cohort 1: Inactivated Vero Cell	118	10.60	3.82	35.80	<0.001	0.05	Significant
Level of Immunity (After Booster)	Cohort 1: Inactivated Vero Cell	118	92.53	0.85				
Level of Immunity (After 1st and 2nd dose)	Cohort 2: Viral S Protein Recombinant	134	51.66	3.37	23.99	<0.001	0.05	Significant
Level of Immunity (After Booster)	Cohort 2: Viral S Protein Recombinant	134	99.82	0.75				

In vaccine cohorts 1 (Inactivated Vero Cell) and 2 (Viral S Protein Recombinant), a paired-samples t-test was conducted to compare the level of immunity after the 1st and 2nd vaccine doses with

the result after the booster shot. In cohort 1, there was a significant difference in the result after the 1st and 2nd doses (M=10.60, SD=3.82) and the result after the booster shot (M=92.53, SD=0.85); t =35.80, p = <0.001. In vaccine cohort 2, there was also a significant difference in the result after the 1st and 2nd doses (M=51.66, SD=3.37) and the result after the booster shot (M=99.82, SD=0.75); t =23.99, p = <0.001. These results suggest that the antibody level significantly increases after a booster shot.

Table 14

Differences on the Participants' Degree of Protection within the Cohort

Variables	Cohort / Vaccine	N	Mean	SD	t value	p value	Significance Level	Interpretation
Degree of Protection (After 1st and 2nd dose)	Cohort 1: Inactivated Vero Cell	118	2.02	0.01	-31.73	<0.001	0.05	Significant
Degree of Protection (After Booster)	Cohort 1: Inactivated Vero Cell	118	5.94	0				
Degree of Protection (After 1st and 2nd dose)	Cohort 2: Viral S Protein Recombinant	134	4.66	0	-8.75	<0.001	0.05	Significant
Degree of Protection (After Booster)	Cohort 2: Viral S Protein Recombinant	134	5.97	0				

In vaccine cohorts 1 (Inactivated Vero Cell) and 2 (Viral S Protein Recombinant), a paired-samples t-test was conducted to compare the degree of protection after the 1st and 2nd vaccine doses with the result after the booster shot. In cohort 1, there was a significant difference in the result after the 1st and 2nd doses (M=2.02, SD=0.01) and the result after the booster shot (M=5.94, SD=0); t = -31.73, p = <0.001. In vaccine cohort 2, there was also a significant difference in the result after the 1st and 2nd doses (M=4.66, SD=0) and the result after the booster shot (M=5.97, SD=0); t =-8.75, p = <0.001. These results suggest that the degree of protection significantly increases after a booster shot.

The efficacy of various vaccines in terms of protection varies as stated by Tregoning et al. (2021), showing that The Pfizer–BioNTech has 100% efficacy for protection (Polack et al., 2020), Viral S Protein Recombinant–the University of Oxford has 100% (Voysey et al., 2021), and Sinovac Biotech has 51-100% depending on disease manifestation (Kim et al., 2021).

Differences in the Level of Immunity and Degree of Protection between Cohorts

The results in tables 15 and 16 provide answers to the question whether there is a significant difference in the level of immunity and degree of protection of the participants after receiving the 1st and 2nd doses of vaccine and a booster shot, between cohorts 1 (Inactivated Vero Cell) and 2 (Viral S Protein Recombinant).

Table 15

Differences on the Participants' Level of Immunity between Cohorts

Variables	Cohort / Vaccine	N	Mean	t value	p value	Significance Level	Interpretation
Level Of Immunity (After 1st and 2nd dose)	Cohort 1: Inactivated Vero Cell	118	10.60	-15.32	<0.001	0.05	Significant
	Cohort 2: Viral S Protein Recombinant	134	51.66				
Level of Immunity (After Booster)	Cohort 1: Inactivated Vero Cell	118	92.53	-5.76	<0.001	0.05	Significant
	Cohort 2: Viral S Protein Recombinant	134	99.82				

The 118 participants who received the 1st and 2nd doses of Inactivated Vero Cell vaccine (M=10.60, SD=3.82) compared to the 134 participants who received the Viral S Protein Recombinant vaccine (M=51.66, SD=3.37), demonstrated a significant difference with the t value of -15.32 and p value of <0.001. It means that Viral S Protein Recombinant provided a higher level of immunity. In addition, the 118 participants who received the booster shot (M=92.53, SD=0.85) compared to the 134 participants who also received booster shot (M=99.82, SD=0.75) demonstrated a significant difference with a t value of -5.76 and a p value of <0.001. It means that the level of immunity among participants in cohort 2 is higher than that of participants in cohort 1.

In the article by Tregoning et al. (2021), it was stated that the currently approved vaccines tested mostly on the adult population have been extremely effective in preventing COVID-19, particularly severe disease. Protection can be in the form of prevention from acquiring the infection, or prevention from having severe or critical cases.

Table 16

Difference on the Participants' Degree of Protection between Cohorts

Variables	Cohort / Vaccine	N	Mean	t value	p value	Significance Level	Interpretation
Degree of Protection (After 1st and 2nd dose)	Cohort 1: Inactivated Vero Cell	118	2.02	18.36	<0.001	0.05	Significant
	Cohort 2: Viral S Protein Recombinant	134	5.94				
Degree of Protection (After Booster)	Cohort 1: Inactivated Vero Cell	118	4.66	1.49	0.068	0.05	Not Significant
	Cohort 2: Viral S Protein Recombinant	134	5.97				

The 118 participants who received the 1st and 2nd doses of Sinovac (M=2.02, D=0.01) compared to the 134 participants who received Viral S Protein Recombinant (M=5.94, SD=0) demonstrated a significant difference with a t value of 18.36 and a p value of <0.001. It means that Viral S Protein Recombinant provided a higher level of immunity. On the other hand, the 118 participants from the cohort 1 who received the booster (M=4.66, SD=0) compared to the 134 participants in cohort 2 who also received the booster (M=5.97, SD=0) demonstrated no significant difference with a t value of 1.49 and a p value of 0.068. It means that the degree of protection after a booster shot between 2 cohorts is statistically similar.

In the study of Barda et al. (2021), their findings suggest that a third dose of the BNT162b2 mRNA vaccine is effective in protecting individuals against severe COVID-19-related outcomes, compared with receiving only two doses at least 5 months ago.

Relationship between the Level of Immunity and Degree of Protection

The results in tables 17 and 18 provide answers to the question of whether there is a significant relationship between the level of immunity and degree of protection among the participants in each cohort after receiving the 1st and 2nd doses of vaccine and a booster shot.

Table 17

Relationship between Level of Immunity and Degree of Protection after 1st and 2nd Doses

Cohort Vaccine 1: Inactivated Vero Cell		Level of Immunity (After 1st and 2nd dose)	Degree of Protection (After 1st and 2nd dose)
Level of Immunity (After first and second dose)	Pearson Correlation	1	-.748**
	Sig. (2-tailed)		.000
	N	118	118
Degree of Protection (After first and second dose)	Pearson Correlation	-.748**	1
	Sig. (2-tailed)	.000	
	N	118	118

Cohort Vaccine 2: Viral S Protein Recombinant		Level of Immunity (After 1st and 2nd dose)	Degree of Protection (After 1st and 2nd dose)
Level of Immunity (After first and second dose)	Pearson Correlation	1	-.535**
	Sig. (2-tailed)		.000
	N	134	134
Degree of Protection (After first and second dose)	Pearson Correlation	-.535**	1
	Sig. (2-tailed)	.000	
	N	134	134

The level of immunity and degree of protection are found to be positively correlated at the 0.01 level (2-tailed), after the 1st and 2nd doses, both in cohort 1, r = -0.748, and cohort 2, r = -0.535. It means that the higher the level of immunity, the higher is the degree of protection.

Table 18

Relationship between Level of Immunity and Degree of Protection after Booster Shot

Cohort Vaccine 1: Inactivated Vero Cell		Level of Immunity (After 1st and 2nd dose)	Degree of Protection (After 1st and 2nd dose)
Level of Immunity (After booster shot)	Pearson Correlation	1	-.481**
	Sig. (2-tailed)		.000
	N	118	118
Degree of Protection (After booster shot)	Pearson Correlation	-.481**	1
	Sig. (2-tailed)	.000	
	N	118	118

In cohort 1, the level of immunity and degree of protection are found to be positively correlated at the 0.01 level (2-tailed) after the booster shot, r = -0.48. It means that the higher the level of immunity, the higher is the degree of protection.

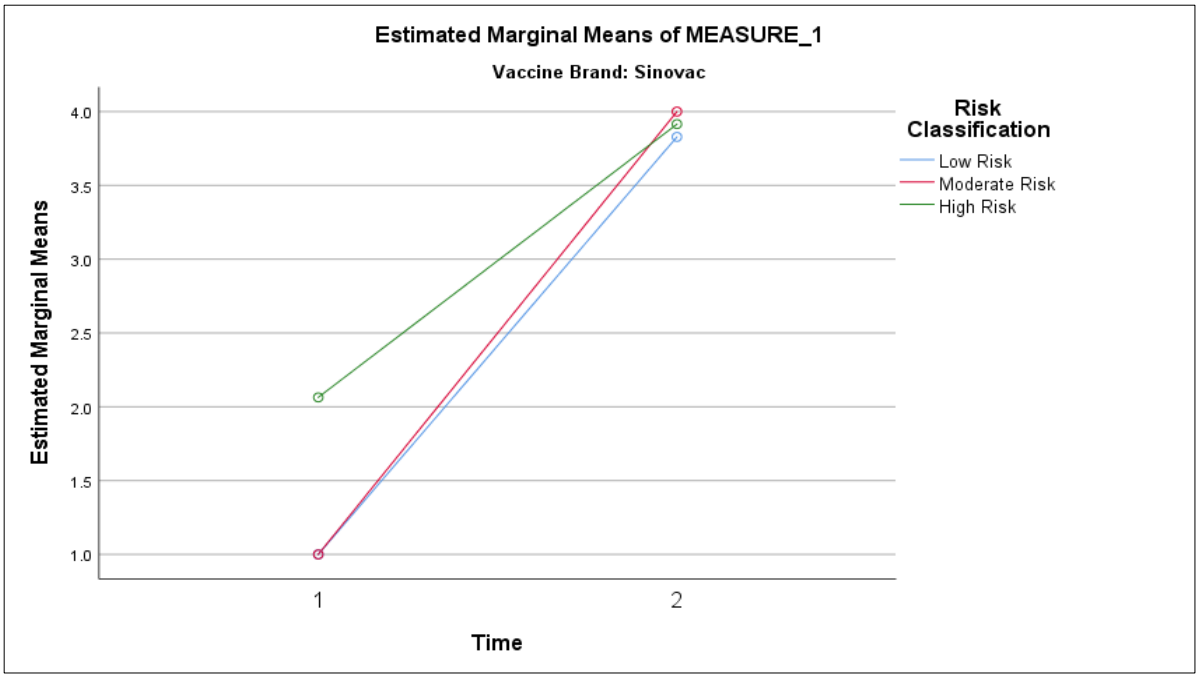
Existing modeling studies have projected that neutralizing antibodies are greatly prognostic of protection against severe COVID-19 infection (Khoury et al. 2021). Other scientific model suggesting a fitted correlation between neutralizing antibody levels and reported efficacy across numerous vaccine trials (Earle et al., 2021). The work of Feng et al. (2021) suggested that data from efficacy trials has demonstrated that both binding and neutralizing antibody titers correlate with protection against the virus or the disease itself.

Effects of the Moderating Variables in the Level of Immunity and Degree of Protection Among Participants

The results in Figure 6-17 present the effects of moderating variables like risk classification, living arrangement, and comorbidities on the level of immunity and degree of protection among participants in Cohorts 1 and 2.

Figure 6

Differences in the Level of Immunity in Cohort 1 after 1st and 2nd Doses of Vaccine if Participants are Grouped According to Risk Classification



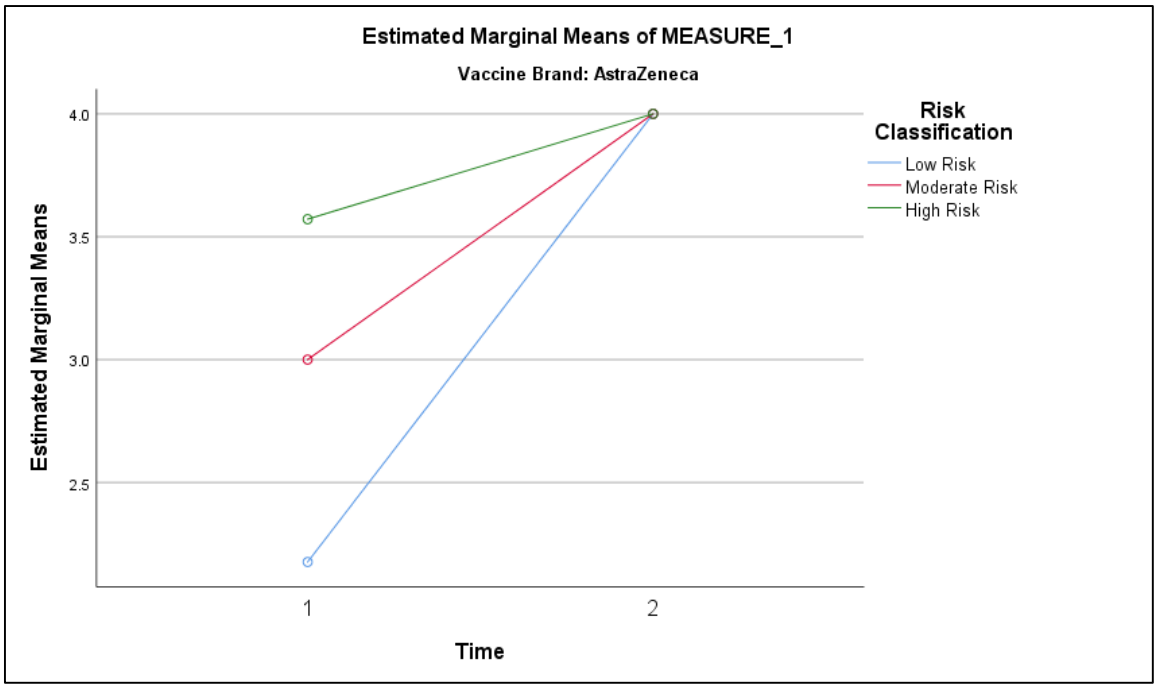
Vaccine / Cohort	Risk Classification	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 10.62	Interpretation
Cohort 1:	T1: Low Risk	35	2.11	2.03	25.02	T_1:T_2	0.33	Not Significant

Inactivated Vero Cell	T2: Risk	Mod	36	2.44	2.10	T_1:T_3	21.06	Significant
	T3: Risk	High	47	23.17	24.70	T_2:T_3	20.73	Significant

A one-way ANOVA was used to compare the effect of risk classification on the level of immunity in cohort 1.The data shows that it has a significant effect on the level of immunity at the p<.05 level for the 3 conditions (F(2, 115) = 25.02, p=,0.001). Post hoc comparisons using the Tukey HSD test indicated that the mean score for high risk (M = 23.17, SD = 24.70) was significantly different from the low risk (M = 2.11, SD = 2.03) and moderate risk (M=2.44, SD=2.10). Though, the low-risk condition did not significantly differ from the moderate risk conditions. Overall, these results suggest that risk classification does have an effect on the level of immunity after a Inactivated Vero Cell vaccine is given.

Figure 7

Differences in the Level of Immunity in Cohort 2 after 1st and 2nd Doses of Vaccine if Participants are Grouped According to Risk Classification

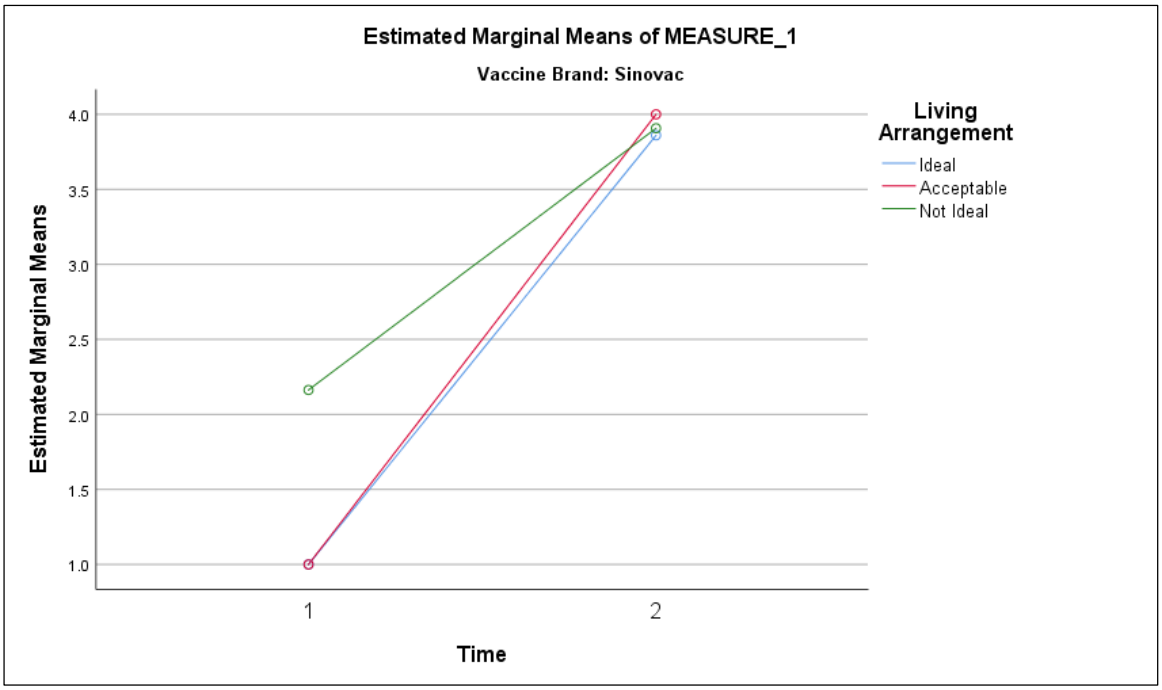


Vaccine / Cohort	Risk Classification		N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 10.0897	Interpretation
Cohort 2: Viral S Protein Recombinant	T1: Risk	Low	34	27.41	15.57	84.46	T_1:T_2	17.18	Significant
	T2: Risk	Mod	37	44.59	9.22		T_1:T_3	41.49	Significant
	T3: Risk	High	63	68.90	18.14		T_2:T_3	24.31	Significant

To compare the moderating effect of risk classification on the level of immunity in cohort 2, a one-way ANOVA was used .The data shows that it has a significant effect on the level of immunity at the p<.05 level for the 3 conditions (F(2, 131) = 84.45631, p=,0.00001). Post hoc comparisons using the Tukey HSD test specified that the mean score for high risk (M = 68.90, SD = 18.14) was significantly different than the low risk (M = 27.41, SD = 15.57) and moderate risk (M=44.59, SD=9.22. Generally, these results suggest that risk classification does have a significant effect on the level of immunity after an Viral S Protein Recombinant vaccine is given. The results suggest that an individual at high risk developed more antibodies because they are constantly exposed to the viral pathogen. Constant exposure increases the production of antibodies thus providing more immunity. This is supported by the data from the work of Urbanowicz et al. (2021), about COVID-19 vaccines; wherein their findings suggest that repetitive exposure to the viral protein / antigen, whether by natural means, or boosting, the production of antibody and its corresponding protective role will be enhanced. It also denotes that giving booster shots provides better immunity than having only 2 doses. This generally recommends that a third or fourth vaccine shots may be helpful in refining the body's immune response against COVID-19 viral pathogen and strengthen the body's resistance against its complications.

Figure 8

Differences in the Level of Immunity in Cohort 1 after 1st and 2nd Doses if Participants are Grouped According to Living Arrangement



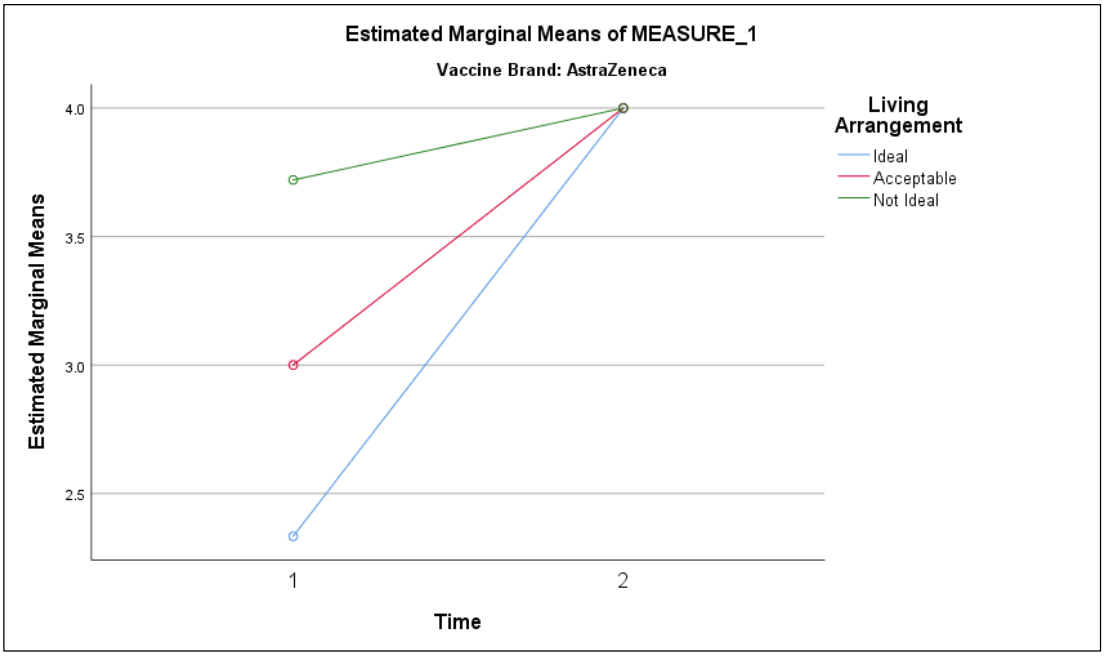
Vaccine / Cohort	Living Arrangement	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 10.34	Interpretation
Cohort 1:	T1: Ideal	43	2.09	1.95	29.66	T_1:T_2	0.72	Significant
	T2: Acceptable	32	2.81	2.21		T_1:T_3	22.81	Significant

Inactivated Vero Cell	T3: Not Ideal	43	23.91	25.14		T_2:T_3	22.09	Significant

Using one-way ANOVA, the effect of living arrangements on the level of immunity in cohort 1 was taken. Data shows that it has a significant effect on the level of immunity at the p<.05 level for the three conditions (F(2, 115) = 29.66, p=,0.001). Post hoc comparisons using the Tukey HSD test showed that the mean score for the not ideal (M = 24.91, SD = 25.14) was significantly different than the ideal condition (M = 2.09, SD = 1.95), and acceptable condition (M=2.81, SD=2.21). Still, the ideal condition did not significantly differ from the acceptable condition. These results suggest that living arrangements does have an effect on the level of immunity after a Inactivated Vero Cell vaccine is given.

Figure 9

Differences in the Level of Immunity in Cohort 2 after 1st and 2nd Doses if Participants are Grouped According to Living Arrangement

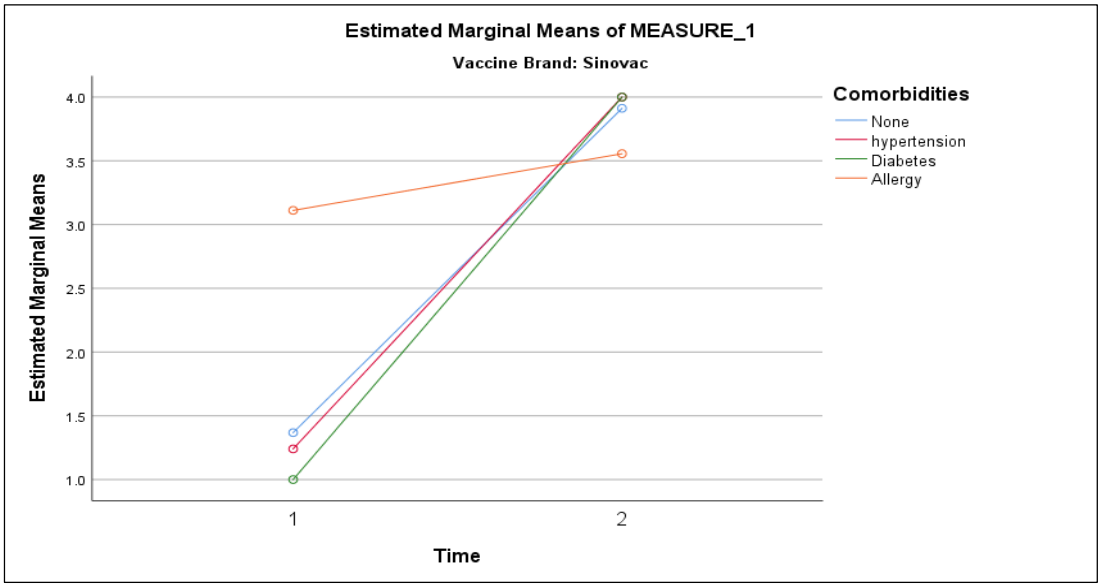


Vaccine / Cohort	Living Arrangement	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 9.59	Interpretation
Cohort 2: Viral S Protein Recombinant	T1: Ideal	42	31.83	16.88	89.61	T_1:T_2	13.81	Significant
	T2: Acceptable	42	45.64	6.98		T_1:T_3	41.55	Significant
	T3: Not Ideal	50	73.38	18.49		T_2:T_3	27.74	Significant

Using one-way ANOVA, the effect of living arrangements on the level of immunity in cohort 2 was made. The data shows that it has a significant effect on the level of immunity at the p<.05 level for the three conditions (F(2, 131) = 89.61, p = 0.001). Post hoc comparisons using the Tukey HSD test showed that the mean score for the not ideal condition (M = 24.91, SD = 25.14), ideal condition (M = 2.09, SD = 1.95), and acceptable condition (M=2.81, SD=2.210 significantly differs from each other. These results suggest that living arrangements does have an effect on the level of immunity after an Viral S Protein Recombinant vaccine is given.

Figure 10

Differences in the Level of Immunity in Cohort 1 after 1st and 2nd Doses if Participants are Grouped According to Comorbidities



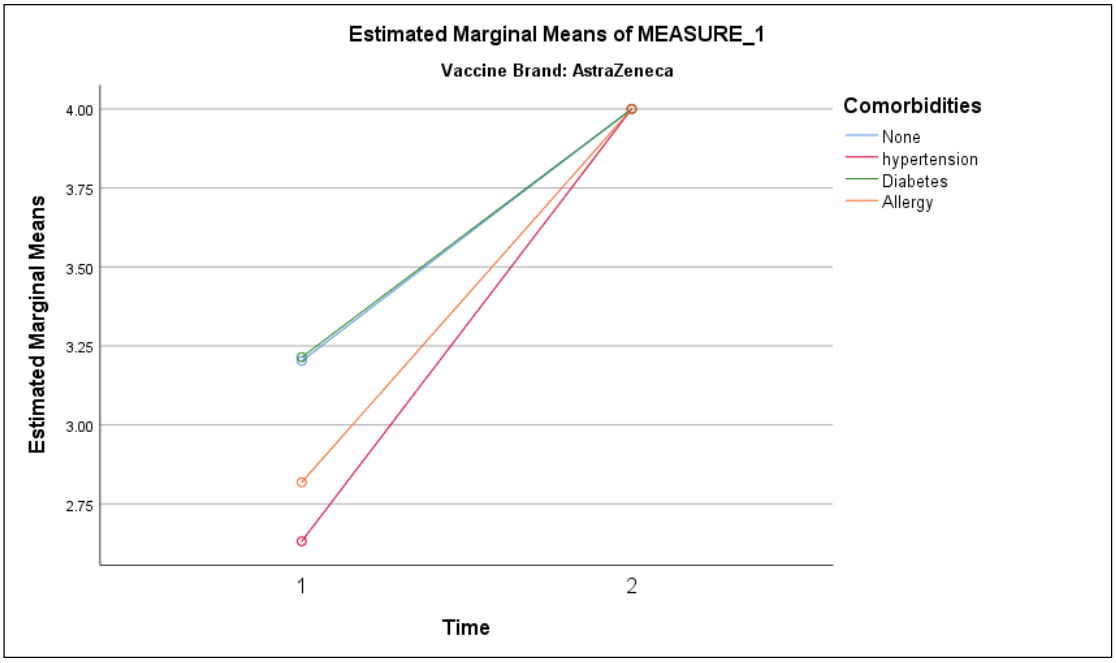
Vaccine / Cohort	Comorbidities	N	Mean	SD	F	Tukey HSD	HSD.01 = 9.59	Interpretation
Cohort 1: Inactivated Vero Cell	T1: No-comorbidity	68	9.22	17	20.01	T_1:T_2	2.54	Not Significant
	T2: Hypertension	25	6.68	2		T_1:T_3	7.41	Not Significant
	T3: Diabetes	16	1.81	12		T_1:T_4	38.34	Significant
	T4: Allergy	9	47.56	0		T_2:T_3	4.87	Not Significant
						T_2:T_4	40.88	Significant
						T_3:T_4	45.74	Significant

A one-way ANOVA was conducted to compare the effect of comorbidities on the level of immunity in cohort 1.It shows that comorbidities has significant effect on the level of immunity at the p<.05 level for the 4 conditions (F(3, 114) = 20.01, p= 0.001). Post hoc comparisons using the Tukey HSD test indicated that the mean score for the allergy condition (M = 47.56, SD = 22.34) was significantly different from the no comorbidities (M = 9.22, SD = 17.89), hypertension (M=6.68,

SD=7.02), and diabetes (M=1.81, SD=1.94). However, the diabetes condition did not significantly differ from the hypertension and no comorbidities conditions. Taken together, these results suggest that comorbidities do have an effect on the level of immunity after a Inactivated Vero Cell vaccine is given. Specifically, the results suggest that immune-related comorbidities, such as an allergy, can enhance antibody production.

Figure 11

Differences in the Level of Immunity in Cohort 2 after 1st and 2nd Doses if Participants are Grouped According to Comorbidities

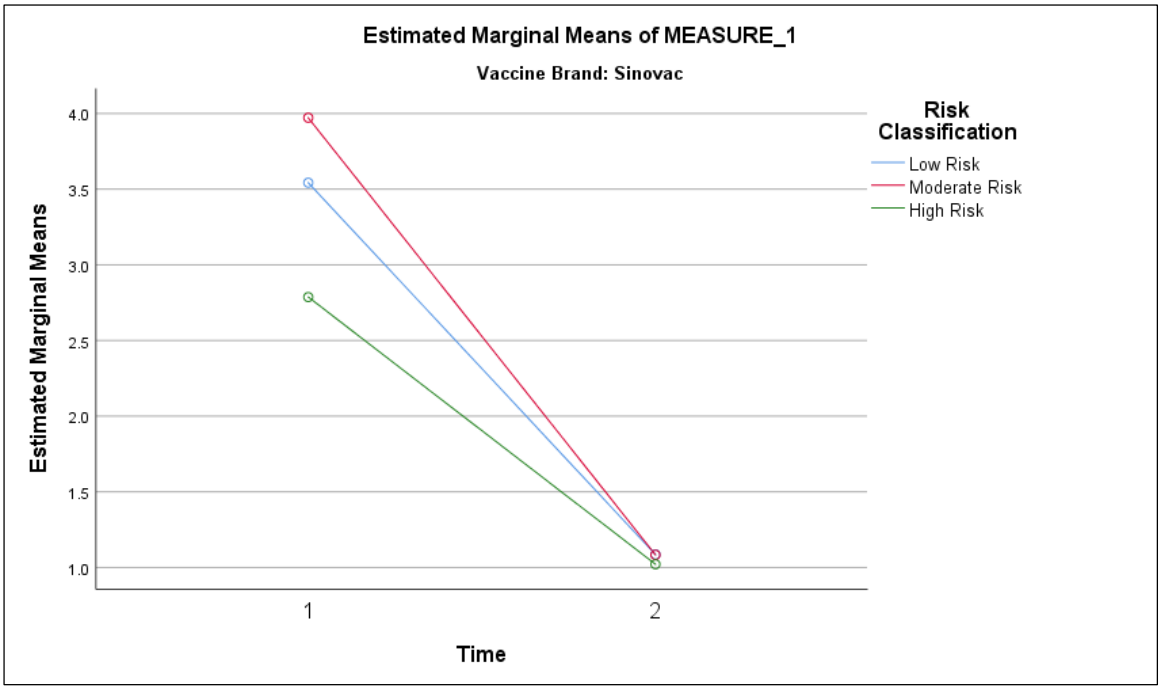


Vaccine / Cohort	Comorbidities	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$	Interpretation
Cohort 2: Viral S Protein Recombinant	T1: No-comorbidity	79	53.08	16.22	2.14	T_1:T_2		
	T2: Hypertension	19	43.95	26.93		T_1:T_3		
	T3: Diabetes	14	62.14	25.68		T_1:T_4		
	T4: Allergy	22	46.59	35.51		T_2:T_3		

A one-way ANOVA was conducted to compare the effect of comorbidities on the level of immunity in cohort 2.The data shows that comorbidities has no significant effect on the level of immunity at the p<.05 level for the four conditions (F(3, 130) = 2.14, p=,0.10). This result suggest that comorbidities do not have an effect on the level of antibody productions using Viral S Protein Recombinant brand of vaccine.

Figure 12

Differences in the Degree of Protection in Cohort 1 after 1st and 2nd Doses of Vaccine if Participants are Grouped According to Risk Classification

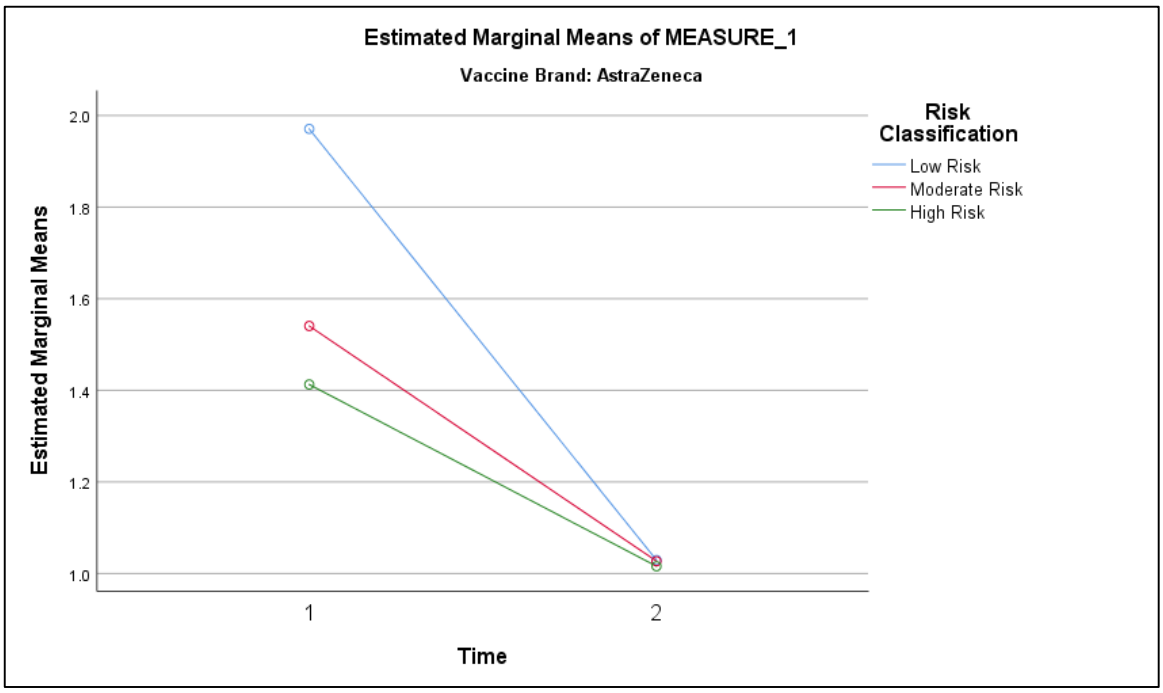


Vaccine / Cohort	Risk Classification	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 0.41	Interpretation
Cohort 1: Inactivated Vero Cell	T1: Low Risk	35	3.54	2.03	41.62	T_1:T_2	0.43	Significant
	T2: Mod Risk	36	3.97	2.10		T_1:T_3	0.76	Significant
	T3: High Risk	47	2.79	24.70		T_2:T_3	1.19	Significant

One-way ANOVA was used to compare the effect of risk classification on the degree of protection in cohort 1.The data shows that it has a significant effect on the level of immunity at the p<.05 level for the 3 conditions (F(2, 115) = 41.62, p=,0.001). Post hoc comparisons using the Tukey HSD test presented that the mean score for low risk (M = 3.54, SD = 0.56), moderate risk (M=3.97, SD=0.17), and high risk (M = 2.79, SD = 0.81) significantly differs from each other. These results suggest that risk classification does have an effect on the degree of protection after a Inactivated Vero Cell vaccine is given.

Figure 13

Differences in the Degree of Protection in Cohort 2 after 1st and 2nd Doses of Vaccine if Participants are Grouped According to Risk Classification

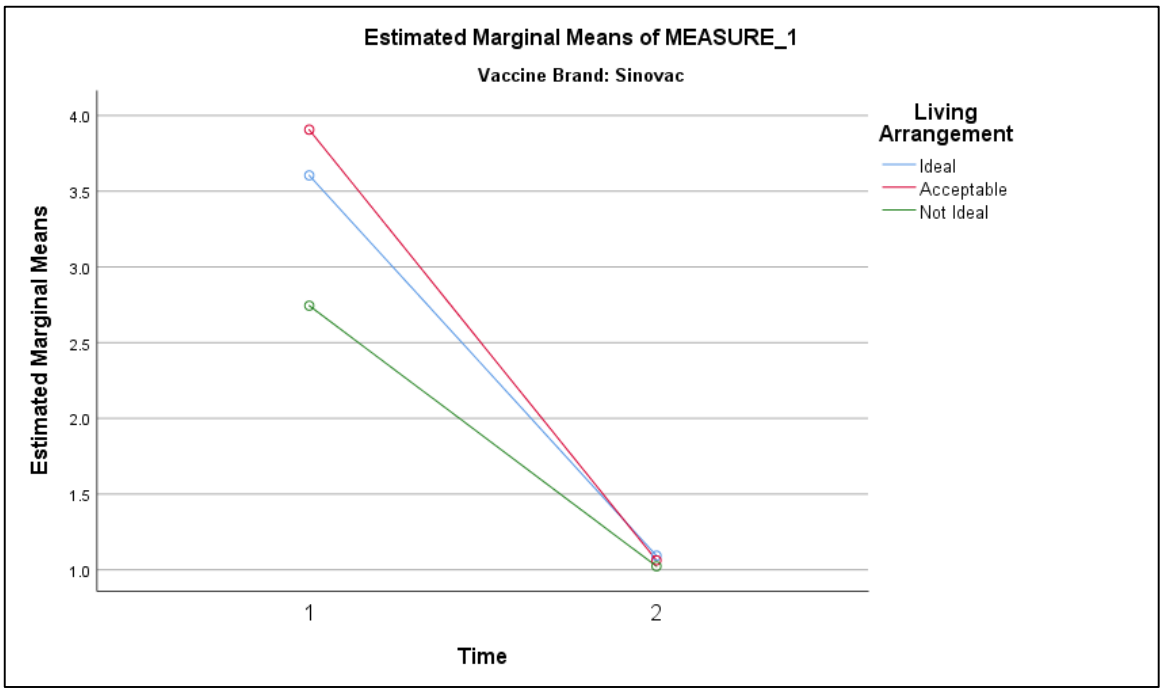


Vaccine / Cohort	Risk Classification		N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ = 0.42	Interpretation
Cohort 2: Viral S Protein Recombinant	T1: Risk	Low	34	1.97	1.09	6.60	T_1:T_2	0.43	Significant
	T2: Risk	Mod	37	1.54	0.51		T_1:T_3	0.56	Significant
	T3: Risk	High	63	1.41	0.59		T_2:T_3	0.13	Not Significant

To compare the effect of risk classification on the degree of protection in cohort 2, a one-way ANOVA was used .The data shows that it has a significant effect on the level of immunity at the $p<.05$ level for the 3 conditions ($F(2, 131) = 6.60$, $p=0.002$. Post hoc comparisons using the Tukey HSD test specified that the mean score for low risk ($M = 1.97$, $SD = 1.09$) was significantly different from the moderate risk ($M = 1.54$, $SD = 0.51$) and high risk ($M=1.41$, $SD=0.59$. But, the effect of moderate condition does not differ from that of high risk classification. In general, risk classification does have a significant effect on the level of immunity after an Viral S Protein Recombinant vaccine is given.

Figure 14

Differences in the Degree of Protection in Cohort 1 after 1st and 2nd Doses if Participants are Grouped According to Living Arrangement

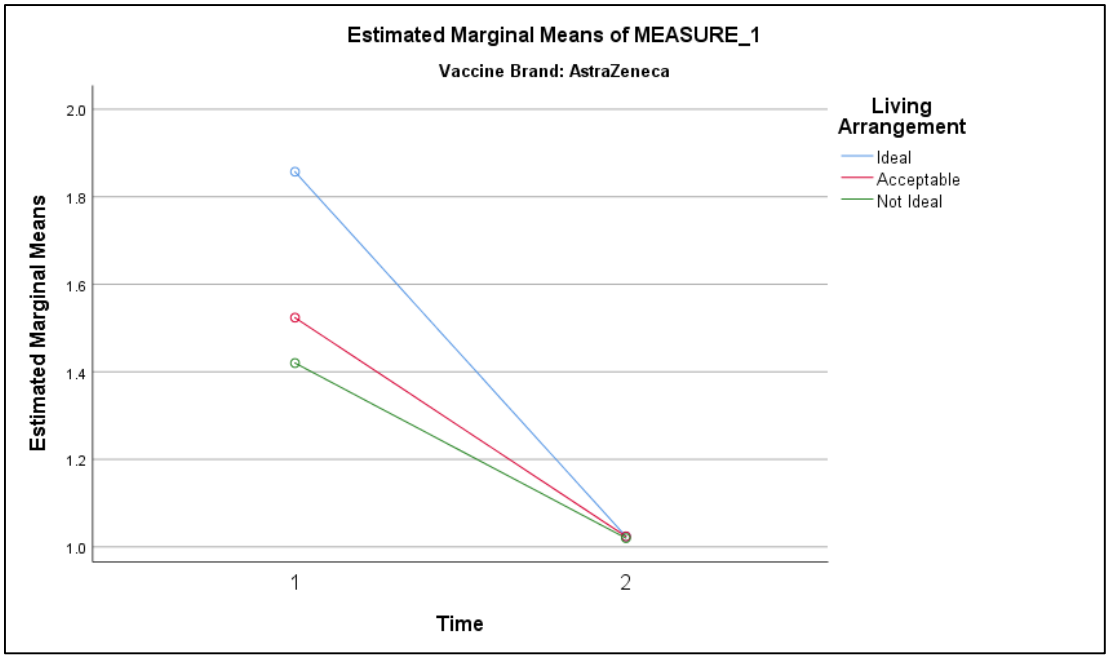


Vaccine / Cohort	Living Arrangement	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ =0.42	Interpretation
Cohort 1: Inactivated Vero Cell	T1: Ideal	43	3.60	0.56	37.83	T_1:T_2	0.30	Not Significant
	T2: Acceptable	32	3.91	0.17		T_1:T_3	0.86	Significant
	T3: Not Ideal	43	2.79	0.81				
						T_2:T_3	1.16	Significant

Using one-way ANOVA, the effect of living arrangements on the degree of protection in cohort 1 was taken. Data shows that it has a significant effect on the degree of protection at the $p<.05$ level for the three conditions ($F(2, 115) = 37.83$, $p= 0.001$). Post hoc comparisons using the Tukey HSD test displayed that the mean score for the not ideal ($M = 2.74$, $SD = 0.82$) was significantly different than the ideal condition ($M = 3.60$, $SD = 0.54$), and acceptable condition ($M=3.91$, $SD=0.30$). Still, the ideal condition did not significantly differ from the acceptable condition. These results suggest that living arrangements do not have an effect on the degree of protection after a Inactivated Vero Cell vaccine is given.

Figure 15

Differences in the Degree of Protection in Cohort 2 after 1st and 2nd Doses if Participants are Grouped According to Living Arrangement

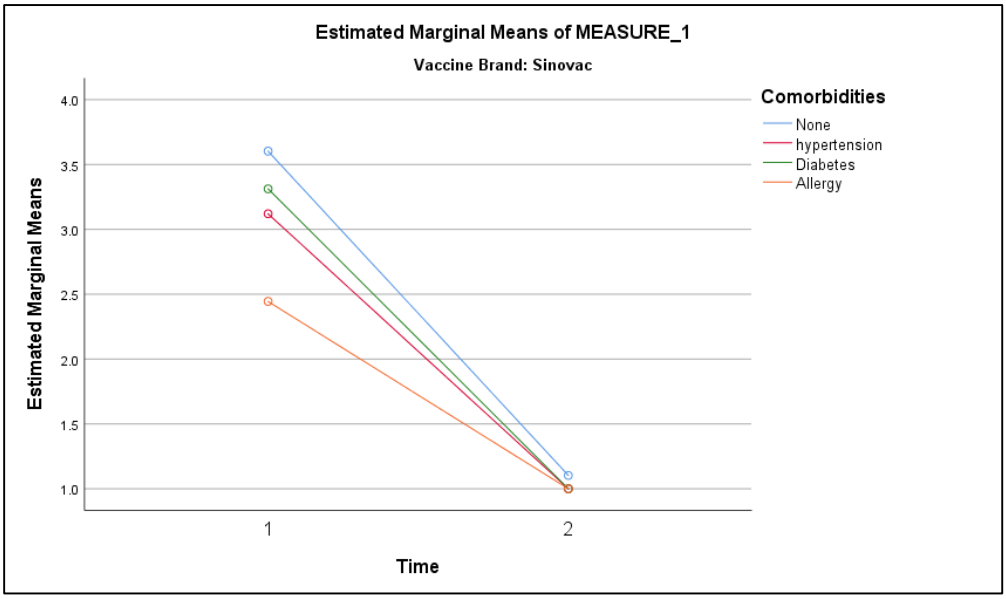


Vaccine / Cohort	Living Arrangement	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ 0.42	Interpretation
Cohort 2: Viral S Protein Recombinant	T1: Ideal	42	1.86	1.03	4.22	T_1:T_2	0.33	Not Significant
	T2: Acceptable	42	1.52	0.51		T_1:T_3	0.44	Significant
	T3: Not Ideal	50	1.42	0.61		T_2:T_3	0.10	Not Significant

Using one-way ANOVA, the effect of living arrangements on the degree of protection in cohort 2 was accounted. The data shows that it has a significant effect on the degree of protection at the $p<.05$ level for the three conditions ($F(2, 131) = 4.22$, $p = 0.017$). Post hoc comparisons using the Tukey HSD test showed that the mean score of ideal condition ($M = 1.86$, $SD = 1.03$) and acceptable condition ($M = 1.52$, $SD = 0.51$) significantly differs from each other. On the other hand, there is no significant difference between ideal and acceptable conditions and between acceptable and not ideal conditions. These results suggest that living arrangements do have an effect on the degree of protection after an Viral S Protein Recombinant vaccine is given.

Figure 16

Differences in the Degree of Protection in Cohort 1 after 1st and 2nd Doses if Participants are Grouped According to Comorbidities

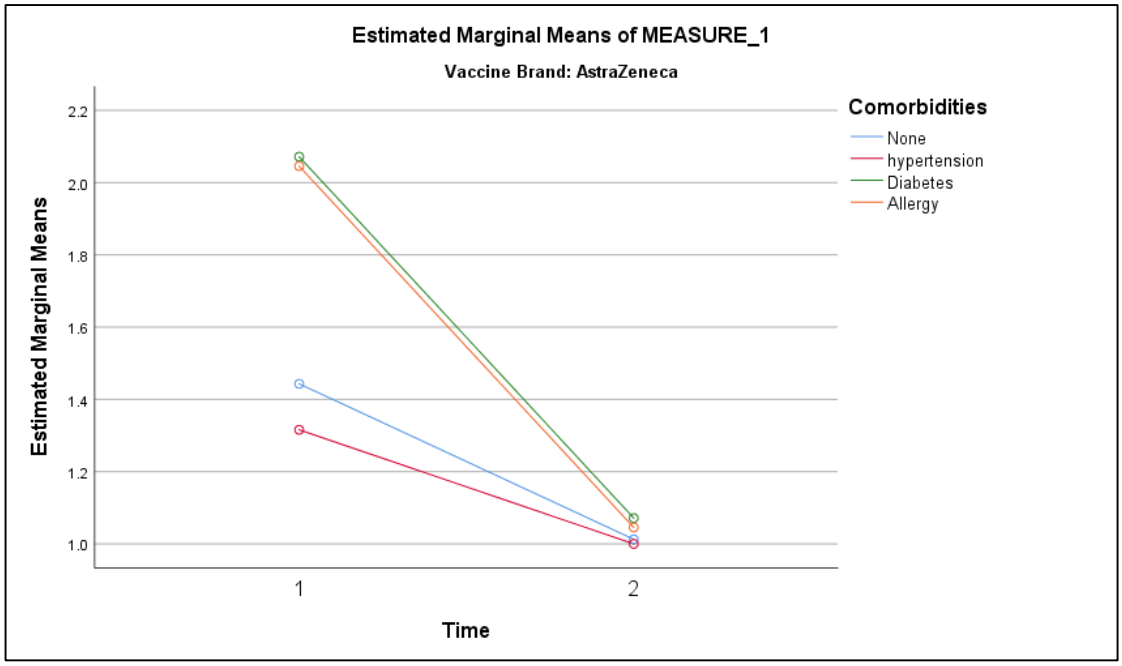


Vaccine / Cohort	Comorbidities	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ =0.51	Interpretation
Cohort 1: Inactivated Vero Cell	T1: No-comorbidity	68	3.60	0.74	8.44	T_1:T_2	0.48	Not Significant
	T2: Hypertension	25	3.12	0.73		T_1:T_3	0.29	Not Significant
	T3: Diabetes	16	3.31	0.48		T_1:T_4	1.16	Significant
	T4: Allergy	9	2.44	0.88		T_2:T_3	0.19	Not Significant
						T_2:T_4	0.68	Significant
						T_3:T_4	0.87	Significant

A one-way ANOVA was conducted to compare the effect of comorbidities on the degree of protection in cohort 1.The data shows that it has significant effect on the degree of protection at the $p<.05$ level for the four conditions ($F(3, 114) = 8.44$, $p= 0.001$). Post hoc comparisons using the Tukey HSD test indicated that the mean score for the allergy condition (M=2.44, SD = 0.88) was significantly different than the no comorbidities (M=3.60, SD = 0.74), hypertension (M=3.12, SD=0.73), and diabetes (M=3.31, SD=0.48). However, the diabetes condition did not significantly differ from the hypertension and no comorbidities conditions. Taken together, these results suggest that comorbidities do have an effect on the degree of protection after a Inactivated Vero Cell vaccine is given.

Figure 17

Differences in the Degree of Protection in Cohort 2 after 1st and 2nd Doses if Participants are Grouped According to Comorbidities



Vaccine / Cohort	Comorbidities	N	Mean	SD	F	Tukey HSD	$HSD_{.01}$ =0.51	Interpretation
Cohort 1: Inactivated Vero Cell	T1: No-comorbidity	79	1.44	0.74	7.24	T_1:T_2	0.13	Not Significant
	T2: Hypertension	19	1.32	0.73		T_1:T_3	0.63	Significant
	T3: Diabetes	14	2.07	0.48		T_1:T_4	0.60	Significant
	T4: Allergy	22	2.05	0.88		T_2:T_3	0.76	Significant
						T_2:T_4	0.73	Significant
						T_3:T_4	0.03	Not Significant

A one-way ANOVA was conducted to compare the effect of comorbidities on the degree of protection in cohort 2.The data show that comorbidities have a significant effect on the degree of protection at the p<.05 level for the four conditions (F(3, 130) = 7.24, p=,0.001). This result suggests that comorbidities have a significant effect on the degree of protection using the Viral S Protein Recombinant brand of vaccine. Post hoc comparisons using the Tukey HSD test indicated that the mean score for those with no comorbidities (M = 1.44, SD = 0.50) was significantly different that of those with diabetes (M = 2.07, SD = 1.00) and allergy (M=2.05, SD=1.17), but had no significant difference from that of those with hypertension (M=1.32, SD=0.48). The mean score of hypertension has a significant difference than from of diabetes and allergy. In addition, results for diabetes and allergy conditions showed no significant difference. Taken together, these results suggest that comorbidities do have an effect on the degree of protection after an Viral S Protein Recombinant vaccine is given.

Theoretically, exposure to germs is thought to help strengthen the immune system and protect an individual from developing illness from viral infection. According to the WHO, those who are exposed

to the public, like taking public transportation and living closely with other people, are at high risk of contracting the virus. From the work of Yelin et al. (2021), analysis showed that lower antibody concentrations were consistently associated with immunosuppression (0·44, 0·33–0·58), and other specific comorbidities: diabetes (0·88, 0·79–0·98), hypertension (0·90, 0·82–0·98), heart disease (0·86, 0·75–1·00), and autoimmune diseases (0·82, 0·73–0·92).

3. Summary of Findings

The healthcare workers who received the 1st and 2nd doses of Inactivated Vero Cell vaccine did not develop immunity, while those who received Viral S Protein Recombinant developed moderate immunity. After the booster shot, participants from both cohorts have high immunity. On the other hand, the participants who received the 1st and 2nd doses of Inactivated Vero Cell vaccine are protected from the infection, while those who received Viral S Protein Recombinant are highly protected. After the booster shot, participants from both cohorts are highly protected.

The participants' level of immunity after the booster shot is significantly higher than that after receiving the 1st and 2nd doses of Inactivated Vero Cell or Viral S Protein Recombinant vaccines. Also, the participants' degree of protection after the booster shot is significantly higher than that after receiving the 1st and 2nd doses of Inactivated Vero Cell or Viral S Protein Recombinant vaccines. 67

The participants' level of immunity in cohort 2 (Viral S Protein Recombinant) is significantly higher from that of cohort 1 (Inactivated Vero Cell) after the 1st and 2nd doses and after the booster shot. Similarly, the participants' level of immunity in cohort 2 (Viral S Protein Recombinant) is significantly higher from that of cohort 1 (Inactivated Vero Cell) after the 1st and 2nd doses. While the participants' level of immunity after the booster shot has no significant difference between the 2 cohorts.

The participants' level of immunity is positively correlated with the degree of protection. It shows that the higher the level of immunity, the higher the degree of protection. Risk classification has a significant effect on the level of immunity. High-risk individuals developed more antibodies than moderate-risk or low-risk individuals.

Living arrangements have a significant effect on the level of immunity. Those with not-so ideal living arrangements developed more immunity than those with acceptable or ideal conditions. Comorbidities, especially allergy, have a significant effect on the level of immunity among participants receiving the Inactivated Vero Cell vaccine, while they have no significant effect among those receiving the Viral S Protein Recombinant vaccine.

Risk classification has a significant effect on the degree of protection. High-risk individuals are better protected than moderate-risk or low-risk individuals. Living arrangements have a significant effect on the degree of protection. Those with not-so ideal living arrangements are better protected than those with acceptable or ideal conditions. Comorbidities have a significant effect on the degree of protection. Those with allergies are more protected than diabetic, hypertensive, and healthy individuals.

4. Conclusion

Considering the results of the study, it could be concluded that generally, COVID-19 vaccines are effective in terms of providing immunity and protection among healthcare workers against the disease. Furthermore, receiving booster shots will increase the level of immunity and degree of protection. The degree of protection has positive correlation with the level of immunity.

5. Recommendations

Based on the findings and conclusion of the study, the following are highly recommended:

1. Viral S Protein Recombinant vaccine is recommended over the Inactivated Vero Cell vaccine
2. All healthcare workers must be given a booster shot.
3. It is recommended to cascade the results of this study to the community to make them aware of the significance of vaccination and getting a booster shot.
4. That the results of this study be given to policy-makers and authorities to provide them significant data for their strategic planning and COVID-19 management initiatives.
5. For other researchers, they may use this as baseline data for other related research like monitoring the antibodies' waning, stability, and agility.
6. It is suggested that the results of this study be used scholarly in planning for COVID-19 vaccination strategies and COVID vaccine management.

those who received Viral S Protein Recombinant are highly protected. After the booster shot, participants from both cohorts are highly protected.

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72

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