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Evaluation of Hypertension Treatment in Patients Who Have Received mRNA-based Covid-19 Vaccines

apt Ainur Rizkiya
Universitas 17 Agustus 45 Jakarta, Indonesia
Email: ainur.rizkiya@gmail.com

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ABSTRACT

Hypertension remains one of the leading global public health problems and is a major risk factor for cardiovascular disease. The widespread implementation of COVID-19 vaccination, particularly mRNA-based vaccines, has raised concerns regarding potential cardiovascular effects, including transient blood pressure changes. This study aimed to evaluate hypertension treatment outcomes in patients who had received mRNA-based COVID-19 vaccines and to analyze the influence of sociodemographic factors on clinical outcomes. A quantitative analytic study with a retrospective cross-sectional design was conducted using electronic medical records from 400 adult hypertensive patients who received Pfizer or Moderna vaccines. Data included blood pressure measurements before and after vaccination, number of antihypertensive medications, comorbidities, and sociodemographic characteristics. Statistical analysis was performed using non-parametric tests. The results showed no statistically significant difference in the number of antihypertensive drugs before and after vaccination (median 2.00; $p = 0.451$). There were also no significant associations between sociodemographic variables and post-vaccination blood pressure, except a limited association with systolic blood pressure in patients with comorbidities. Overall, mRNA COVID-19 vaccination did not significantly affect antihypertensive therapy requirements or blood pressure control. These findings support the safety of mRNA vaccination in hypertensive patients, although continued monitoring, particularly of systolic blood pressure in patients with comorbid conditions, remains recommended.

INTRODUCTION

Hypertension, or high blood pressure, is one of the non-communicable diseases that constitutes a global public health problem. The World Health Organization (WHO) notes that about 1.28 billion adults worldwide have hypertension, and nearly two-thirds of them live in low- and middle-income countries (World Health Organization, 2021). Hypertension is an example of a non-communicable disease that can cause serious health problems, to the extent that it is referred to as the "silent killer." If hypertension is not managed under the supervision of a physician, it can affect vital organs, causing complications such as stroke, kidney disorders, heart attacks, and blindness (Abbafati et al., 2020).

Hypertension is a condition in which blood pressure persistently exceeds the normal threshold (≥140/90 mmHg) and is often referred to as a silent killer because it does not present obvious symptoms until serious complications occur. The global burden of hypertension is enormous. According to WHO, as of 2023, there are around 1.28 billion adults aged 30–79 years living with hypertension, with the majority (two-thirds) residing in low- and middle-income countries (World Health Organization, 2023a).

This number has continued to increase significantly since 1990. Between 1990 and 2019, the prevalence of hypertension increased from 650 million to more than 1.3 billion adults, most of whom are in developing countries (World Health Organization, 2023b). By 2025, it is estimated to reach 1.5 billion cases, with very low control rates—fewer than 20% of hypertensive patients have controlled blood pressure (The Times of India, 2025).

The results of the 2023 Indonesian Health Survey (SKI), published by the Ministry of Health and BKPK, show that the prevalence of hypertension in the population aged ≥18 years is 30.8%, decreasing from 34.1% in Riskesdas 2018. SKI 2023 also noted that only 5.9% of respondents aged 18–59 years were diagnosed with hypertension by a physician, while this percentage is higher (22.9%) among those aged ≥60 years.

For younger age groups, the 2023 SKI showed prevalence based on blood pressure measurements as follows: ages 18–24 years: 10.7%; ages 25–34 years: 17.4%. Although there has been a national decrease in hypertension prevalence, the overall rate remains relatively high. Meanwhile, prevalence among younger individuals indicates that hypertension is not only a problem affecting the elderly.

Hypertension is a major risk factor for cardiovascular diseases such as heart attack, stroke, heart failure, and chronic kidney disease. Each year, hypertension is estimated to account for about 10 million premature deaths, with only 21% of patients achieving adequate control, and nearly half unaware of their condition (Health.com, 2023). Hypertension not only affects individual health but also imposes an economic burden on healthcare systems and reduces national productivity.

The COVID-19 pandemic has posed a major challenge to global public health since its emergence in late 2019. The disease impacts not only mortality and morbidity but also health, social, and economic systems worldwide. In efforts to control the spread of the SARS-CoV-2 virus, vaccination has been the primary intervention relied upon (AboulFotouh, Cui and Williams, 2021; Uddin and Roni, 2021).

One of the most significant technological achievements in COVID-19 vaccine development is the messenger RNA (mRNA) vaccine platform. This type of vaccine offers a novel approach to immunization, with advantages such as rapid production, flexibility of modification, and high effectiveness in eliciting an immune response. The two main products of this platform are BNT162b2 (Comirnaty) from Pfizer-BioNTech and mRNA-1273 (Spikevax) from Moderna. Both became the first mRNA vaccines to be widely used globally and have received emergency use authorization from the FDA, WHO, and various national health authorities since the end of 2020.

The mRNA vaccine works by delivering genetic instructions to human cells to produce the SARS-CoV-2 spike protein, which is then recognized by the immune system, triggering the formation of antibodies and virus-specific T cells. This technology differs from conventional approaches that use attenuated or inactivated viruses, as mRNA vaccines do not contain live or inactivated viruses and therefore do not carry a risk of causing infection (Pardi et al., 2021).

The effectiveness of mRNA vaccines has been demonstrated in various clinical trials and field studies, particularly in preventing severe disease, hospitalization, and death from COVID-19. However, their implementation has also opened avenues for further research, including the potential for certain side effects such as myocarditis, transient hypertension, and inflammatory

immune responses, which require further investigation in diverse populations (Alahmad, Beiram and Aburuz, 2021).

COVID-19 vaccination has become an important milestone in global pandemic control. Alongside the successful implementation of mass vaccination—especially with mRNA platforms such as Pfizer-BioNTech (BNT162b2) and Moderna (mRNA-1273)—reports of adverse events following immunization (AEFI) have also emerged, including those involving the cardiovascular system (Harrison, Coffman and Wilcox, 2021; Touyz et al., 2020; Zuin et al., 2020).

Reports of cardiovascular side effects after mRNA vaccination mainly include myocarditis and pericarditis, which are more commonly reported in younger individuals, especially males, after the second dose. Most cases are mild to moderate and resolve with supportive treatment (Bozkurt et al., 2021; Patone et al., 2022). Additionally, there have been reports of acute increases in blood pressure (transient hypertension), palpitations, tachycardia, and arrhythmias, most of which occur within 48 hours of vaccination (Zappa et al., 2022; Yousaf et al., 2022).

The biological mechanisms underlying these possible side effects are not yet fully understood but are thought to involve inflammatory immune responses, activation of the sympathetic nervous system, and oxidative stress due to the release of proinflammatory cytokines (IL-6, TNF-α). Inflammasome activation and endothelial dysfunction are also believed to contribute to temporary increases in blood pressure in susceptible individuals (Sung et al., 2023).

Although the benefits of vaccination far outweigh the risks of rare side effects, close monitoring and further studies remain necessary, particularly for populations with cardiovascular comorbidities such as hypertension. Therefore, it is important to evaluate the clinical impact of mRNA vaccination on patients with cardiovascular conditions, especially in the context of medical record-based research related to Evaluation of Hypertension Treatment in Patients Who Have Received mRNA-based Covid-19 Vaccines.

Hypertension is one of the most common chronic diseases worldwide and is a major contributor to cardiovascular diseases such as stroke and coronary heart disease (Mills et al., 2021). Management of hypertension requires regular monitoring, adherence to therapy, and control of triggers, including systemic and inflammatory stress. In the context of the COVID-19 pandemic, new challenges have arisen for populations with hypertension, particularly after mass vaccination using mRNA technology (Baden et al., 2021; Corbett et al., 2020; Sahin et al., 2020).

mRNA-based COVID-19 vaccines (such as Pfizer-BioNTech and Moderna) have been shown to be highly effective in preventing severe infection. However, some reports mention temporary increases in blood pressure, palpitations, and even post-vaccination hypertensive crises, particularly in individuals with a history of hypertension or cardiovascular disease (Zappa et al., 2022; Buso et al., 2022). Although rare, these reactions raise important questions regarding the effectiveness and safety of both short- and long-term antihypertensive treatments in vaccinated patients within the scope of Evaluation of Hypertension Treatment in Patients Who Have Received mRNA-based Covid-19 Vaccines.

Evaluation of post-vaccination hypertension treatment outcomes is essential to determine whether vaccination affects blood pressure stability, the effectiveness of antihypertensive

medications, or necessitates therapeutic adjustments (Dolgin, 2021; Kisby, Yilmazer and Kostarelos, 2021). It also helps clinicians develop individualized treatment approaches for hypertensive patients who will receive or have received vaccination. Moreover, vaccine-induced systemic inflammation can affect vascular regulation and blood pressure homeostasis, especially in patients with existing vascular susceptibility (Sung et al., 2023), which is highly relevant to Evaluation of Hypertension Treatment in Patients Who Have Received mRNA-based Covid-19 Vaccines.

Pharmacovigilance, or drug safety surveillance, is critically important in the context of mRNA-based COVID-19 vaccines such as Pfizer-BioNTech (BNT162b2) and Moderna (mRNA-1273). These vaccines are developed using relatively new technologies that have not previously been used widely in mass vaccination (Angeli et al., 2022; Ferrara et al., 2022; Mevorach et al., 2021). Although clinical trials demonstrate high efficacy, large-scale global deployment requires rigorous monitoring of short- and long-term side effects that may not have been detected during trials.

Pharmacovigilance is essential to identify rare or unexpected adverse reactions, such as myocarditis, pericarditis, or increased blood pressure following vaccination; assess the risk–benefit profile continuously as real-world data emerge, including in vulnerable populations (older adults, individuals with comorbidities, and adolescents); increase public trust through transparent, evidence-based communication; and adjust clinical recommendations, such as booster dosing intervals or contraindications for specific groups (Ferrara et al., 2022).

Global pharmacovigilance reporting systems such as VAERS (United States), Yellow Card (United Kingdom), and EudraVigilance (European Union) play a crucial role in detecting safety signals. Through pharmacovigilance data analysis, regulators can take rapid actions, such as issuing warnings, revising labels, or suspending vaccine distribution if necessary (Ferrara et al., 2022).

In the era of mass vaccination and increasing global hypertension prevalence, data-driven studies based on medical records examining clinical outcomes of post-vaccination hypertension treatment are important to improve healthcare quality, prevent complications, and support updated evidence-based therapeutic guidelines. The limited availability of such information further justifies the need for research.

The urgency of this research is driven by several factors. First, hypertension is highly prevalent globally and in Indonesia, affecting nearly one-third of the adult population. Second, the widespread use of mRNA vaccines has raised clinical questions regarding potential effects on blood pressure stability and antihypertensive therapy effectiveness. Third, vaccine-induced systemic inflammation may influence vascular regulation and blood pressure homeostasis, particularly in patients with preexisting vascular susceptibility (Sung et al., 2023).

Based on the issues described, this study was designed to examine whether there are changes in antihypertensive drug regimens or additions to therapy after patients receive an mRNA-based COVID-19 vaccine, as well as to analyze how sociodemographic characteristics—such as age, sex, employment status, and education level—affect clinical outcomes in vaccinated hypertensive patients (Efriza, 2021). The general objective of this study is to evaluate hypertension treatment and its contribution to clinical outcomes following mRNA-based COVID-19 vaccination. Specific objectives include identifying changes or additions in antihypertensive therapy after vaccination and analyzing the influence of

sociodemographic factors on patient outcomes. This study is expected to provide theoretical contributions to understanding the relationship between mRNA-based COVID-19 vaccination and hypertension management, as well as practical benefits for healthcare professionals and policymakers in managing hypertensive patients undergoing vaccination, particularly in therapeutic evaluation and monitoring of potential complications.

METHOD

The method used in this thesis is an analytical quantitative approach with a retrospective design that collects data through electronic medical records (ERM) for samples of patients with hypertension and a special polyclinic database for mRNA-based vaccinated patients. Cross-sectional studies to measure factors contributing to clinical outcomes.

1. Target population.

   Adult hypertensive patients who have been given mRNA-based vaccines.
2. Criteria included:
   a. Age ≥18 years old
   b. Hypertensive patients
   c. Receiving an mRNA-based vaccine (Pfizer or Moderna)
   d. Have an electronic-Medical Record (ERM).
   e. Patients with comorbidities of degenerative diseases (heart, diabetes,)
3. Exclusion criteria:
   a. Incomplete blood pressure data
   b. Secondary hypertension
   c. Patients with severe comorbidities that may affect the outcome of therapy (e.g., hypertensive patients with advanced renal failure, cancer, autoimmune diseases and HIV-Aids).
4. Data Collection Techniques
   a. e-RM Study
   b. Variables: Type of vaccine, blood pressure before/after vaccine, type of hypertension drug, comorbidities

The research is planned to last for 3-6 months starting with the submission of a proposal permit to the UTA 45 Jakarta Master of Pharmacy Study Program, followed by the management of ethical clearance. After obtaining approval, the researcher submitted a research cover letter along with a proposal and ethical clearance to Pertamina Central Hospital and Jakarta Port Hospital until they obtained a permit to conduct the research. The next stage is data collection through questionnaires and patient medical records retrospectively, followed by collection, processing, data analysis, discussion of results, and drawing conclusions.

The research was carried out at Pertamina Central Hospital and Jakarta Port Hospital in the period of August 2025 to February 2026. The stages of the activity include submitting titles, preparing proposals, managing research permits, observation/data collection, data analysis, and drawing conclusions which are carried out in stages according to the research schedule.

Data were obtained through an electronic medical record (e-RM) analysis with variables including the type of vaccine, blood pressure before and after vaccination, type of antihypertensive drug, and comorbidities. The analysis was conducted descriptively to describe the number of patients who had received the mRNA vaccine and post-vaccination blood

pressure conditions, bivariate analysis to assess the relationship between vaccine type and blood pressure control, and multivariate analysis to predict factors influencing patient clinical outcomes.

RESULT AND DISCUSSION

A. Test of Normality of Data on the Number of Drug Use Before and After Vaccination

In this study, as many as 400 samples were carried out by examining electronic medical records (EMR). The data from the EMR was obtained in accordance with the sample data that the mRNA vaccine had done in 2022. Details of the sample population include sociodemographics such as gender, age group, patient comorbid status and education status.

Before data analysis in the form of a statistical test, a data normality test was carried out from the relationship between the number of drug use before and after vaccination which was associated with sociodemographics. Normality tests are performed to determine the type of statistical test used in data analysis. The results of the normality test showed that the data was distributed abnormally, so a non-parametric test was used.

B. Distribution of Research Subjects Based on Sociodemographics

To be able to provide an overview in the form of the number of distribution of research subjects based on gender, age group, comorbid status, education level and the number of drugs before and after vaccination based on the status of drug regimen changes, will be explained in the form of a graph.

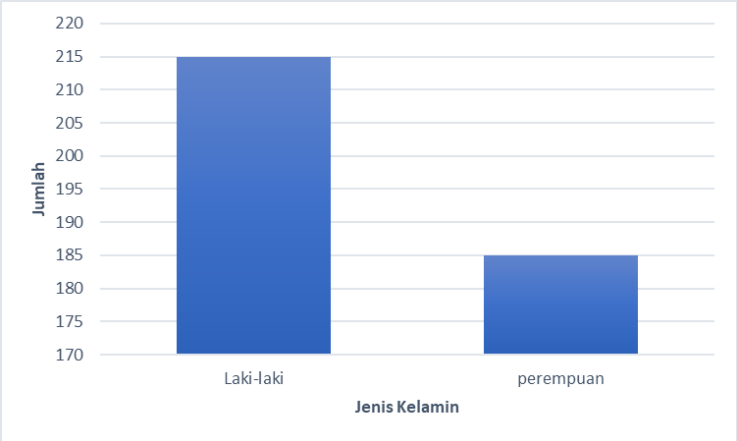

Figure 1. Graph of the distribution of research subjects by gender

Figure 1 shows a graph of the number of distribution of research subjects by gender with a larger number of male sex samples than female sex. The number of males was 215 samples and the number of females was 185 samples.

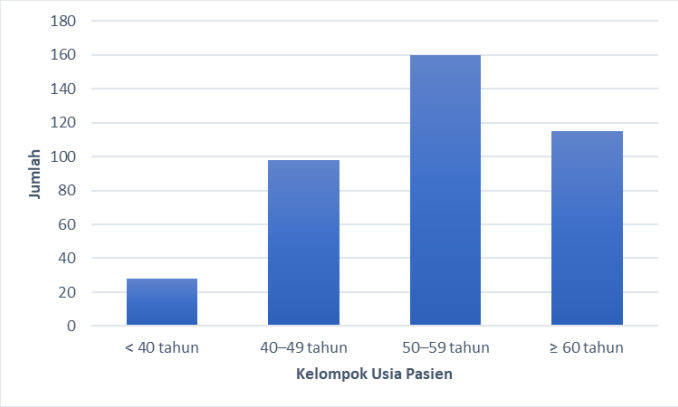

Figure 2. Graph of the distribution of research subjects by age of the patient (years)

Figure 2 shows a graph of the age distribution of the study subjects. Most of the subjects were in the adult to elderly age range, with the greatest concentration in the middle to upper age group before the elderly 50 - 59 years.

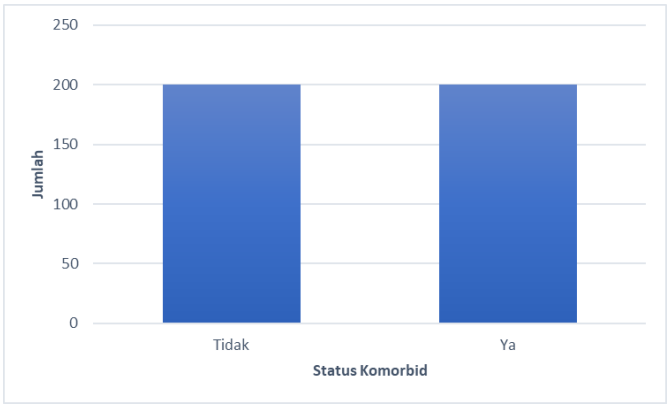

Figure 3. Graph of the distribution of research subjects based on comorbid status

Figure 3 shows a graph of the distribution of comorbid status in the study subjects. The number of subjects with comorbidities and without comorbidities was the same.

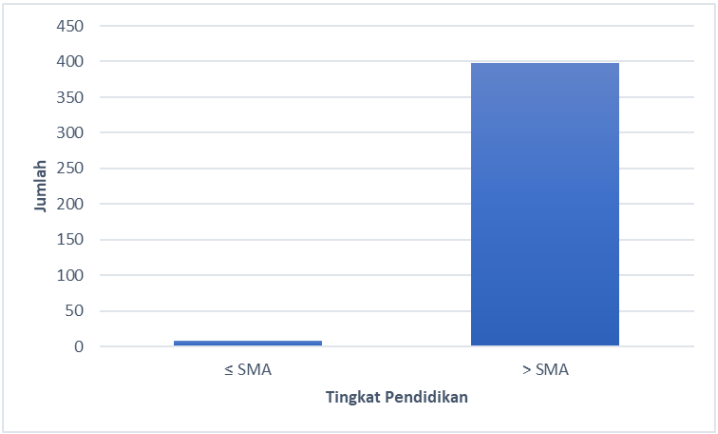

Figure 4. Graph of the distribution of research subjects by level of Education

Figure 4 shows the distribution of the education level of the research subjects. Most subjects have an education level above high school, while only a small percentage of subjects have a high level of education ≤. This shows that the majority of the research subjects come from groups with secondary to higher education levels.

To illustrate the difference in the average amount of drugs used before and after vaccination, a descriptive analysis was carried out based on the status of drug changes. The average distribution of pre-vaccine and post-vaccine drugs was grouped based on drug changes, namely the group without drug change and the group with drug change. The results of the analysis are presented in the form of a grouped bar graph.

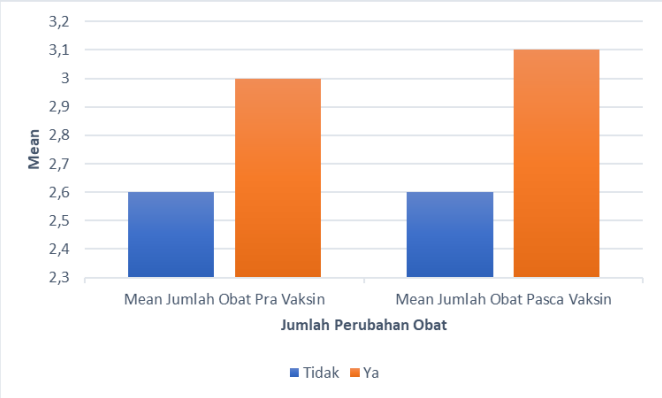

Figure 5. Graph of the distribution of research subjects by number of drug changes

Figure 5 shows a comparison graph of the average number of drugs before and after vaccination based on the status of changes in the drug regimen. In subjects who did not experience a change in regimen, the average amount of medication before and after vaccination was relatively the same. In contrast, in subjects who experienced a change in regimen, the average number of post-vaccination drugs appeared to be higher than before vaccination.

C. Statistical tests on the relationship between the number of drug use before and after vaccination based on sociodemographics.

1. Number of drugs before vs number of drugs after (Wilcoxon Signed-Rank Test)

Table 1. Wilcoxon Test Results Change in the Number of Drugs Before and After Vaccination

Variabel	Median	p-value
Number of Drugs Before Vaccine	2,00	**0,451***
Number of Drugs After Vaccination	2,00	

*wilcoxon

In Table 1 table based on the results of the normality test, the distribution of data on the number of drugs before and after vaccination was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Wilcoxon Signed-Rank Test. The results of the descriptive analysis showed that the median number of drugs before vaccination was 2.00 which means that half of the study subjects used at least 2 types of drugs and most of the patients were in the range of 1 to 2 types of drugs before vaccination.

After vaccination, the median number of drugs also remained at 2.00, with a relatively similar distribution of the number of drugs, where most patients remained on 1 to 2 types of drugs. This shows that in terms of distribution, the pattern of drug use before and after vaccination has relatively not changed. The Wilcoxon test on 400 patients showed a p=0.451 value, indicating that there was no statistically significant difference between the number of drugs before and after mRNA-based COVID-19 vaccination.

These findings suggest that mRNA-based COVID-19 vaccination was not followed by a statistically significant change in the number of drugs in hypertensive patients. Thus, the overall treatment regimen of patients remained stable after vaccination, and no indication of the need for systematic adjustment of the amount of medication was found in the study population.

2. Gender vs Number of Drugs Before Vaccine (Mann–Whitney U Test)

Table 2. Mann–Whitney Test Results Differences in the Number of Drugs Before Vaccines by Gender

Variabel	Median	p-value
Male	2,00	**0,731***
Women	2,00	

*Mann-Whitney

In Table 2, based on the results of the normality test, the distribution of the number of drugs before vaccination by sex was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs before vaccination in male patients was 2.00, as well as the median number of drugs before vaccination in female patients was 2.00.

This median value indicates that the median value of the number of drugs in both groups was in two types of drugs, meaning that about half of patients used two or fewer drugs and the other half used two or more drugs, in both the male and female groups. The similarity of the median value indicates that descriptively the pattern of drug use before the vaccine is relatively similar between the two sexes.

The results of the Mann–Whitney test showed a p value = 0.731, indicating that there was no statistically significant difference between the number of drugs before vaccination in male and female patients. These findings suggest that sex was not associated with variations in the amount of drugs before vaccination, so the difference in the number of drugs used before vaccination was not influenced by sex factors in the study population.

3. Gender vs Number of Drugs After Vaccine (Mann–Whitney U Test)

Table 3. Results of the Mann–Whitney Test Differences in the Number of Drugs After Vaccine by Gender

Variabel	Median	p-value
Male	2,00	**0,805**
Women	2,00	

*Mann-Whitney

In Table 3, based on the results of the normality test, the distribution of data on the number of drugs after vaccination based on sex was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs after vaccination in male patients was 2.00, as well as the median number of drugs after vaccination in female patients was 2.00.

The median value shows that the median value of the number of drugs after vaccination in both groups is in two types of drugs, which means that about half of patients use two or fewer drugs and the other half use two or more drugs, in both the male and female groups. The similarity of this median value indicates that descriptively the pattern of drug use after vaccination is relatively similar between the two sex groups.

The results of the Mann–Whitney test showed a value of $p = 0.805$, indicating that there was no statistically significant difference between the number of drugs after vaccination in male and female patients. These findings suggest that sex is not related to variations in the number of drugs after vaccination, so the difference in the number of drugs used after vaccination is not influenced by sex factors in the study population.

4. Age Group vs Number of Drugs Before Vaccine (Kruskal–Wallis Test)

Table 4. Kruskal-Wallis Test Results Differences in the Number of Drugs Before Vaccine by Age Group

Age Group	Median	p-value
< 40 years old	2,00	**0,345***
40–49 years old	2,00	
50–59 years old	2,00	
≥ 60 years old	2,00	

*Kruskal-Valais

In Table 5.4, based on the results of the normality test, the distribution of data on the number of drugs before vaccination based on age group was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Kruskal–Wallis Test. The results of the descriptive analysis showed that the median number of drugs before vaccination in all age groups, namely < 40 years, 40–49 years, 50–59 years, and ≥ 60 years, was 2.00 years respectively.

The same median value across all age groups showed that the median value of the number of drugs before vaccination was in two types of drugs in all age groups. This means that about half of the patients are on two or fewer drugs and the other half are on two or more drugs, with no noticeable differences between age groups. Descriptively, these findings indicate that the pattern of drug use before vaccination is relatively similar across all age groups.

The results of the Kruskal–Wallis test showed a value of $p = 0.345$, indicating that there was no statistically significant difference in the number of drugs before vaccination between age groups. These findings suggest that age was not associated with variations in the amount of medication before vaccination, so the age difference did not affect the number of medications used before vaccination in this study population.

5. Age Group vs Number of Drugs After Vaccine (Kruskal–Wallis Test)

Table 5. Kruskal-Wallis Test Results Differences in the Number of Drugs After Vaccine Based on Age Group

Age Group	Median	p-value
< 40 years old	2,00	**0,257***
40–49 years old	2,00	
50–59 years old	2,00	
≥ 60 years old	2,00	

*Kruskal-Valais

In Table 5, based on the results of the normality test, the distribution of data on the number of drugs after vaccination based on the age group was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Kruskal–Wallis Test. The results of the descriptive analysis showed that the median number of drugs after vaccination in all age groups, namely < 40 years, 40–49 years, 50–59 years, and ≥ 60 years, was 2.00 years each.

The same median value in all age groups indicates that the median value of the number of drugs after vaccination is in two types of drugs in all age groups. This means that about half of patients use two or fewer drugs and the other half use two or more drugs after vaccination. Descriptively, these findings indicate that the pattern of drug use after vaccination is relatively similar across all age groups.

The results of the Kruskal–Wallis test showed a value of $p = 0.257$, which indicates that there was no statistically significant difference in the number of drugs after vaccination between age groups. These findings suggest that age is not associated with variations in the amount of medication after vaccination, so the need for medication use after vaccination is relatively uniform across all age groups in the study population.

6. Comorbidities vs Number of Drugs Before Vaccine (Mann–Whitney U Test)

Table 6. Mann–Whitney Test Results of Differences in the Number of Drugs Before Vaccines Based on Comorbidities

Status Komorbid	Median	p-value
No	2,00	**0,655***
Ya	2,00	

*Mann–Whitney

In Table 6, based on the results of the normality test, the distribution of data on the number of drugs before vaccination based on comorbid status was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs before vaccination in patients without comorbidities was 2.00, while the median number of drugs before vaccination in patients with comorbidities was also 2.00.

The same median value in both groups showed that the median value of the number of drugs before vaccination was in two types of drugs, both in patients with and without

comorbidities. This means that about half of patients use two or fewer drugs and the other half use two or more drugs, regardless of comorbid status. Descriptively, these findings show that the pattern of drug use before vaccination is relatively similar in both groups of comorbid status.

The results of the Mann–Whitney test showed a value of p = 0.655, indicating that there was no statistically significant difference between the number of drugs before vaccination in patients with and without comorbidities. These findings suggest that comorbid status is not related to variation in the amount of medication before vaccination, so the presence of comorbidities does not affect the number of medications used before vaccination in this study population.

7. Comorbidities vs Number of Drugs After Vaccination (Mann–Whitney U Test)

Table 7. Results of the Mann–Whitney Test Differences in the Number of Drugs After Vaccine Based on Comorbidities

Status Komorbid	Median	p-value
No	2,00	**0,799***
Ya	2,00	

*Mann–Whitney

In Table 7, based on the results of the normality test, the distribution of data on the number of drugs after vaccination based on comorbid status was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs after vaccination in patients without comorbidities was 2.00, while the median number of drugs after vaccination in patients with comorbidities was also 2.00.

The similarity of the median values showed that the median value of the number of drugs after vaccination in both groups was in two types of drugs, meaning that about half of the patients used two or fewer drugs and the other half used two or more drugs, in both the group of patients with and without comorbidities. Descriptively, this shows that the pattern of drug use after vaccination is relatively similar in both groups of comorbid status.

The results of the Mann–Whitney test showed a value of p = 0.799, indicating that there was no statistically significant difference between the number of drugs after vaccination in patients with and without comorbidities. These findings suggest that comorbid status is not related to variations in the number of drugs after vaccination, so the presence of comorbidities does not affect the number of drugs patients take after mRNA-based COVID-19 vaccination in this study population.

8. Education Level vs Number of Drugs Before Vaccine (Mann–Whitney U Test)

Table 8. Results of the Mann–Whitney Test Differences in the Number of Drugs Before Vaccines Based on Education Level

Education Level	Median	p-value
≤ SMA	2,00	**0,963***
> SMA	2,00	

*Mann–Whitney

In Table 8, based on the results of the normality test, the distribution of data on the number of drugs before vaccination based on education level was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs before vaccination in patients with high school ≤ education level was 2.00, as well as the median number of drugs before vaccination in patients with high school > education level of 2.00.

The same median value in both education groups showed that the median value of the number of drugs before vaccination was on two types of drugs, meaning that about half of the patients used two or fewer drugs and the other half used two or more drugs, in both the education groups ≤ high school and high school >. Descriptively, this shows that the pattern of drug use before vaccination is relatively similar between education level groups.

The results of the Mann–Whitney test showed a p = value of 0.963, indicating that there was no statistically significant difference between the number of drugs before vaccination in patients with high school ≤ and high school > education levels. These findings suggest that education level was not associated with variations in the number of drugs before vaccination, so differences in educational background did not affect the number of drugs patients took before mRNA-based COVID-19 vaccination in this study population.

9. Education Level vs Number of Drugs AfterVaccine (Mann–Whitney U Test)

Table 9. Mann–Whitney Test Results Differences in the Number of Drugs After Vaccine Based on Education Level

Education Level	Median	p-value
≤ SMA	2,00	**0,296***
> High School	2,00	

*Mann–Whitney

In Table 9, based on the results of the normality test, the distribution of data on the number of drugs after vaccination based on education level was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median number of drugs after vaccination in patients with ≤ high school education level was 2.00, as well as the median number of drugs after vaccination in patients with high school > education level of 2.00.

The same median value in both education groups showed that the median value of the number of drugs after vaccination was in two types of drugs, meaning that about half of patients used two or fewer drugs and the other half used two or more drugs, both in the education groups ≤ high school and high school >. Descriptively, these findings show that the pattern of drug use after vaccination is relatively similar between education level groups.

The results of the Mann–Whitney test showed a value of p = 0.296, indicating that there was no statistically significant difference between the number of drugs after vaccination in patients with high school ≤ and high school > education levels. These findings suggest that education level is not related to variations in the number of drugs after vaccination, so educational background does not affect the need for patient drug use after mRNA-based COVID-19 vaccination in this study population.

D. Normality Test of Blood Pressure Data After Vaccination

Before data analysis in the form of a statistical test, a data normality test was carried out from the relationship between blood pressure after vaccination which was associated with sociodemographics. Normality tests are performed to determine the type of statistical test used in data analysis. Based on the results of the normality test, the distribution of post-vaccination systolic and diastolic blood pressure in several sociodemographic groups was not normally distributed ($p \leq 0.05$), thus requiring the use of non-parametric statistical tests.

Thus, the selection of statistical tests in advanced analysis is carried out selectively based on the results of the normality test on each variable, to ensure the accuracy and validity of the data analysis. The normality test in this study aims to determine the appropriate statistical test approach in the subsequent hypothesis analysis, and is not used to draw conclusions about relationships or differences between variables.

E. Statistical test of blood pressure relationship after vaccination based on sociodemographics.

1) Results of the Mann–Whitney Test on the Relationship of Systolic Blood Pressure After Vaccine by Gender

Table 10. Mann–Whitney Test Results on the Relationship of Systolic Blood Pressure After Vaccine
By Gender

Gender	Median	p-value
Male	127,00	**0,387***
Women	128,00	

*Mann–Whitney

In Table 10, based on the results of the normality test, the distribution of systolic blood pressure data after vaccination by sex was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median systolic blood pressure after vaccination in male patients was 127.00 mmHg, while in female patients the median systolic blood pressure after vaccination was 128.00 mmHg.

The relatively similar median values between the two groups showed that the median value of systolic blood pressure after vaccination was in almost the same range between male and female patients. Descriptively, this indicates that there is no marked difference in systolic blood pressure after vaccination by sex.

The results of the Mann–Whitney test showed a value of $p = 0.387$, indicating that there was no statistically significant difference in systolic blood pressure after vaccination between male and female patients. These findings suggest that gender is not associated with systolic blood pressure variation after vaccination, so the systolic blood pressure response after mRNA-based COVID-19 vaccination is relatively similar in both sex groups in this study population.

2) Results of the Mann–Whitney test on the relationship between diastolic blood pressure after vaccine by sex.

Table 11. Results of the Mann–Whitney Test on the Relationship of Diastolic Blood Pressure After Vaccine
By Gender

Gender	Median	p-value
Male	80,00	**0,776***
Women	80,00	

*Mann–Whitney

In Table 11, based on the results of the normality test, the distribution of diastolic blood pressure data after vaccination by sex was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median diastolic blood pressure after vaccination in male patients was 80.00 mmHg, as well as the median diastolic blood pressure after vaccination in female patients was 80.00 mmHg.

The same median value in both groups showed that the median value of diastolic blood pressure after vaccination was 80 mmHg in both male and female patients. Descriptively, this indicates that the distribution of diastolic blood pressure after vaccination is relatively similar in both sex groups.

The results of the Mann–Whitney test showed a value of $p = 0.776$, indicating that there was no statistically significant difference between diastolic blood pressure after vaccination in male and female patients. These findings suggest that sex is not related to diastol blood pressure variation after vaccination, so the diastolic blood pressure response after mRNA-based COVID-19 vaccination is not affected by sex factors in this study population.

3) Results of the Kruskal–Wallis test on the relationship of systolic blood pressure after vaccination by age group.

Table 12. Kruscal–Wallis Test Results of Systolic Blood Pressure Relationship After Vaccine
By Age Group

Age Group	Median	p-value
< 40 years old	126,00	**0,293***
40–49 years old	127,00	
50–59 years old	129,00	
≥ 60 years old	128,00	

*Kruskal–Valais

In Table 12, based on the results of the normality test, the distribution of systolic blood pressure data after vaccination based on age group was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Kruskal–Wallis Test. The results of the descriptive analysis showed that the median systolic blood pressure after vaccination in the age group < 40 years was 126.00 mmHg, in the age group of 40–49 years it was 127.00

mmHg, in the age group of 50–59 years it was 129.00 mmHg, and in the age group of ≥ 60 years was 128.00 mmHg.

The median value showed that the median value of systolic blood pressure after vaccination was in a relatively similar range across all age groups, with a tendency to slightly increase in older age groups. Descriptively, the median differences between age groups appear small and do not show any marked variation.

The results of the Kruskal–Wallis test showed a value of p = 0.293, which indicates that there was no statistically significant difference in systolic blood pressure after vaccination between age groups. These findings suggest that age groups are not significantly associated with variations in systolic blood pressure after vaccination, so the systolic blood pressure response after mRNA-based COVID-19 vaccination is relatively uniform across all age groups in the study population.

4) Results of the Kruskal–Wallis test on the relationship between diastolic blood pressure after vaccine based on age group.

Table 13. Results of the Kruscal–Wallis Test on the Relationship of Diastolic Blood Pressure After Vaccine By Age Group

Age Group	Median	p-value
< 40 years old	80,00	**0,239***
40–49 years old	79,00	
50–59 years old	80,00	
≥ 60 years old	81,00	

*Kruskal–Valais

In Table 13, based on the results of the normality test, the distribution of diastolic blood pressure data after vaccination based on the age group is not normally distributed (p < 0.05), so statistical analysis is carried out using the non-parametric Kruskal–Wallis Test. The results of the descriptive analysis showed that the median diastolic blood pressure after vaccination in the age group < 40 years was 80.00 mmHg, in the age group of 40–49 years it was 79.00 mmHg, in the age group of 50–59 years it was 80.00 mmHg, and in the age group of ≥ 60 years it was 81.00 mmHg.

The median value showed that the median value of diastolic blood pressure after vaccination was relatively similar across all age groups, with very little variation between groups. Descriptively, there was no noticeable difference in diastolic blood pressure after vaccination based on age group.

The results of the Kruskal–Wallis test showed a value of p = 0.239, which indicates that there was no statistically significant difference in diastolic blood pressure after vaccination between age groups. These findings suggest that age groups were not significantly associated with variations in diastolic blood pressure after vaccination, so the diastolic blood pressure response after mRNA-based COVID-19 vaccination was relatively consistent across all age groups in the study population.

5) The results of the Mann–Whitney test on the relationship between systolic blood pressure after vaccination based on education level.

Table 14. Results of the Mann–Whitney Test on the Relationship of Diastolic Blood Pressure After Vaccine
By Education Level

Education Level	Median	p-value
≤ High School	143,00	**0,076***
> High School	128,00	

*Mann–Whitney

In Table 14, based on the results of the normality test, the distribution of diastolic blood pressure data after vaccination based on education level was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median diastolic blood pressure after vaccination in patients with high school ≤ education level was 143.00 mmHg, while in patients with > high school education level the median diastolic blood pressure after vaccination was 128.00 mmHg.

The median value showed that the median value of diastolic blood pressure after vaccination in the ≤ high school education group was higher than the > high school education group. Descriptively, this indicates a difference in the tendency of diastolic blood pressure after vaccination based on education level, although this variation needs to be statistically confirmed.

The results of the Mann–Whitney test showed a p value = 0.076, indicating that there was no statistically significant difference in diastolic blood pressure after vaccination between the ≤ high school and high school > education groups. These findings suggest that education level is not significantly associated with variations in diastolic blood pressure after vaccination, although descriptively there is a tendency for higher median values in groups with lower education levels.

6) The results of the Mann–Whitney test on the relationship between diastolic blood pressure after vaccination based on education level.

Table 15. Results of the Mann–Whitney Test on the Relationship of Diastolic Blood Pressure After Vaccine
By Education Level

Education Level	Median	p-value
≤ SMA	81,00	**0,704***
> SMA	80,00	

*Mann–Whitney

In Table 15, based on the results of the normality test, the distribution of diastolic blood pressure data after vaccination based on education level was not normally distributed ($p < 0.05$), so statistical analysis was carried out using the non-parametric Mann–Whitney U Test. The results of the descriptive analysis showed that the median diastolic blood pressure after

vaccination in patients with high school ≤ education level was 81.00 mmHg, while in patients with > high school education level, the median diastolic blood pressure after vaccination was 80.00 mmHg.

This median value shows that the median value of diastolic blood pressure after vaccination in the two education groups is relatively similar, with very small differences descriptively. This indicates that in general the distribution of diastolic blood pressure after vaccination did not show a marked difference based on education level.

The results of the Mann–Whitney test showed a p value = 0.704, indicating that there was no statistically significant difference in diastolic blood pressure after vaccination between patients with high school ≤ and high school > education levels. These findings suggest that education level is not related to diastolic blood pressure variations after vaccination, so education factors are not the main determinant of diastolic blood pressure changes in this study population.

The results showed that there was no statistically significant difference in the number of drugs before and after mRNA-based COVID-19 vaccination. The median number of drugs remained at two types of drugs at both times of measurement. These findings indicate that vaccination does not lead to the need for systematic escalation of pharmacological therapy in hypertensive patients.

Physiologically, the mechanism of action of mRNA vaccines does not directly affect chronic blood pressure regulatory systems such as the renin–angiotensin–aldosterone system (RAAS), sympathetic activity, or long-term fluid retention. The inflammatory response that arises after vaccination is temporary and generally does not cause persistent hemodynamic changes. Therefore, there was no need for extensive adjustment of drug regimens in this study population.

The absence of a significant difference in diastolic pressure suggests that peripheral resistance is relatively stable, and the therapy regimen used by the patient remains able to adequately control diastolic pressure. These findings are consistent with the pattern of isolated systolic hypertension that is more commonly found in elderly populations and patients with cardiovascular comorbidities.

CONCLUSION

Based on the results of the study, there was no significant difference in the number of antihypertensive drugs before and after mRNA-based COVID-19 vaccination ($p > 0.05$), with a fixed median of two drugs, and sociodemographic factors did not have a significant effect on the number of drugs or blood pressure after vaccination, except for the comorbid relationship with systolic blood pressure. In general, mRNA vaccination is safe in hypertensive patients and does not increase the need for therapy, but systolic blood pressure monitoring in patients with comorbidities is still recommended. Further research needs to expand the sample, conduct multivariate analyses, and add more comprehensive clinical variables.

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