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Relationships between Clinical Outcomes of Coronary Heart Disease of Covid-19 Vaccinated Patients with Hypertension

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Abstract

The effects of COVID-19 vaccination on conventional cardiovascular risk rankings for heart disease patients after inoculation need further investigation especially within Southeast Asian medical settings. The research explored hypertension effects on clinical results in CHD patients after receiving COVID-19 vaccinations at a Jakarta referral hospital in Indonesia. Research investigators conducted an observational cohort study by gathering retrospective and prospective data from January 2022 until May 2024. The clinical investigation evaluated 110 vaccinated patients who had CHD while examining population characteristics, blood pressure status, and their ultimate outcomes between survival and fatal termination. The research included statistical methods that combined Chi-square and Fisher's exact tests for categorical data analysis along with t-tests for age analysis, one-way ANOVA for subgroup analysis, Pearson correlation and binary logistic regression.. Out of the 110 patients screened for hypertension the condition was observed in 93.6%. Among hypertensive patients survival rates reached 91.3% whereas non-hypertensive patients demonstrated survival rates of 57.1% ($p = 0.027$). Age proved significant as a predictor of mortality and recovery duration through continuous analysis ($p = 0.035$; $\beta = 0.42$, $p = 0.002$) even though results were non-significant when patients were grouped as <60 and ≥60 years ($p = 1.000$). The analysis from logistic regression showed that hypertension worked as a positive predictor for patient survival with an OR of 5.33 (95% CI: 1.02–27.79) and $p = 0.047$. The vaccine acts as an acute disease protector yet changes but does not completely eliminate existing cardiovascular disease susceptibilities.

Introduction

Global mortality statistics show Coronary heart disease (CHD) as the leading cause of death because it develops as a result of lifestyle factors alongside environmental elements and systemic factors (Frąk et al., 2022; Prajapati et al., 2021; Dhakal & Pokharel, 2024). The disease persists with determination especially in quickly developing urban areas that face economic changes. Atherosclerotic plaque accumulation leading to progressive coronary artery blockage constitutes the core of coronary heart disease development (Sumiarty & Fitrianingsih, 2020; Rahim et al., 2016). CHD now transcends its traditional singular status because it presents as a metabolic failure that arises from environmental contaminants and nutrition and physical inactivity at various biological and societal systems (Dai et al., 2021; Brown, 2024).

CHD burden has shown a rapid increase in the population of Indonesia. Most patients in 2013 did not have CHD according to Basic Health Research but the 2018 statistics showed a tripled prevalence rate which reached 1.6% in West Java specifically (Ministry of Health of the

Republic of Indonesia, 2018). Economic growth together with widening health inequalities and demographic changes along with changes in food processes and inactivity patterns (Karyatin, 2019; Fitriyatin et al., 2020; Lake et al., 2023) explain such health trends. The increase and disregard of CHD will create a massive human and financial crisis through the next few decades.The establishment of hypertension as a central risk factor classifies it almost universally as a vital factor that leads to coronary heart disease development. Hypertension starts and sustains endothelial dysfunction while causing vascular remodeling and expanding atherosclerotic plaques which constricts coronary arteries (Fuchs & Whelton, 2020; Li et al., 2023; Hall et al., 2024). A long-term rise in blood pressure pressure leads to both left ventricular hypertrophy and diastolic dysfunction that creates conditions for heart ischemia and arrhythmogenesis (Mason, 1978; Marliani, 2013; Marazzato et al., 2022; Bacharova et al., 2023; Đorđević et al., 2024). The mechanism of sustained hypertension includes elevated arterial stress and activation of inflammatory cytokines and augmented oxidative stress that accelerates atherothrombosis (Shao et al., 2020; Naeije et al., 2022; Das et al., 2023).

Epidemiological research demonstrates that inadequate hypertension management produces a powerful effect on patients' cardiovascular diseases. Blood pressure control showed essential importance according to the Prospective Studies Collaboration because each 20 mm Hg elevation in systolic pressure doubled ischemic heart disease death rates (Lewington et al., 2002). Framingham-based research has verified that successful blood pressure reduction leads to reduced occurrences of major adverse cardiac events (Vasan et al., 2017). The prevalence of inadequate medical management among Indonesian hypertensive patients remains low according to Saparina (2019) who conducted surveys which showed that less than half of diagnosed hypertension sufferers failed to receive proper care. The beginning of the COVID-19 pandemic brought highly stressful conditions to cardiovascular health care and exposure risks to vulnerable patients (Duffy et al., 20221). The cardiovascular damage from SARS-CoV-2 extends beyond respiratory complications because it damages heart muscles and both destabilizes arterial plaques and stimulates widespread clot formation (Guo et al., 2020; Shao et al., 2020; Sanchis-Gomar & Harky, 2024). Data demonstrates that people with CHD along with hypertension face very elevated risks for severe COVID-19 illnesses and ICU requirements with increased mortality (Zhou et al., 2020; Dhakal & Pokharel, 2024). Clinical data established that cardiovascular conditions function as dangerous multipliers which enhance the death rate from COVID-19.

The implementation of COVID-19 vaccinations brought historical changes to the way the disease spread through populations. The mRNA vaccines together with the adenoviral vector vaccines succeeded in reducing all outcomes involving severe disease, hospitalizations and mortality according to clinical trials (Polack et al., 2020; Sadoff et al., 2021; Shoushtari et al., 2022; Elkashif et al., 2021). Research indicates that vaccination protects individuals who have CHD alongside other heart diseases yet they still face remaining health risks (Wong et al., 2022; Lu et al., 2021) and (Wong et al., 2022). Post-vaccination treatment reduces viral access but also lessens blood inflammation and protects the endothelial cells which leads to enhanced heart health (Anderson et al., 2020; Sahin et al., 2020; Devaux & Camoin-Jau, 2023).

The solution of vaccination does not address every medical challenge. Real-world evidence shows breakthrough COVID-19 cases among cardiovascular disease patients become less severe yet still expose them to significant health risks (Xie et al., 2022; Liu et al., 2022; Boehme et al., 2024; Ludwig et al., 2024). The effects of vaccination on predicting the clinical importance of standard risk factors such as hypertension remain unclear to medical experts. The established pre-pandemic risk order of CHD patients persists after their bodies develop immunity through vaccination structs. Recent research reveals vaccination alters pathogenic relationships between age, hypertension, and diabetes although it does not completely eliminate

their disease-inducing properties (Singh et al., 2024; Fuady et al., 2021; Fu et al., 2024; KB et al., 2022).

The scientific community lacks studies that investigate how hypertension affects clinical outcomes of CHD patients who received vaccines within middle-income Southeast Asian countries particularly Indonesia. The majority of studies originate from high-income settings whose healthcare delivery systems and vaccination procedures alongside population health indices vary greatly (Dai et al., 2021; Saraswati & Sunarta, 2021; Santangelo et al., 2024). Healthcare facilities worldwide are transforming their COVID-19 acute crisis strategy into continuous comorbidity management therefore it is vital to comprehend these intricate medical patterns. A research investigation at a Jakarta hospital focuses on hypertension effects on clinical results among coronary heart disease patients receiving COVID-19 vaccinations. This study addresses the present knowledge deficit to expand research-based insights regarding cardiovascular management approaches for post-pandemic patient care.

Methods

The researchers employed a combined retrospective-prospective analytic observational cohort method for their research design. The selected hybrid research design covered a full analysis of coronary heart disease patients' medical outcomes after receiving the COVID-19 vaccine especially relating to blood pressure conditions. The researchers enhanced study findings reliability and temporal validity through the combination between retrospective data evaluation and real-time patient monitoring. The research took place in Jakarta at a hospital between January 2022 and May 2024. The prolonged study period enabled researchers to gather information throughout different pandemic stages and periods of vaccine deployment which resulted in enhanced observational diversity.

Adult patients diagnosed clinically with coronary heart disease who received the COVID-19 vaccine formed the study sample. The researchers utilized purposive sampling to select patients who exemplified the most significant criteria required for achieving research objectives. A set of selection criteria determined the patients whose profiles maintained a direct relationship with the research inquiry. The study recruited participants who were eighteen years old or older while having confirmed coronary heart disease and acquiring one vaccine dose for COVID-19. The study participants needed to show their consent to join when researchers followed their progress. The research framework established specific conditions for participant selection so the studied groups would match in disease status and vaccination patterns allowing clear examination of hypertension as a main independent variable. A strict framework existed which determined which cases would be excluded from the sample to preserve methodological integrity. The study excluded any pregnant patient or cancer diagnosis or patients who had HIV/AIDS or autoimmune diseases. The research sample omitted patients with these conditions since their individual effects on immune responses and cardiovascular reactions could potentially interfere with the results analyzing CHD risks associated with COVID-19 vaccine administration in hypertensive patients. Such medical conditions might create invalid research findings because they alter the possible relationships between variables so researchers excluded them to protect sample validity. Study participants met the same exclusion requirements both in the retrospective section and the prospective section to maintain consistent uniformity among samples.

Researchers retrieved the necessary data for the retrospective segment of the study by analyzing medical records and hospitalization records and vaccination documentation maintained at the hospital facility. Research assistants with specialized training gathered essential information from the database which contained patient demographics together with diagnosis information and treatment backgrounds and health results. Through historical follow-up this review collected data regarding CHD patients who received COVID-19 vaccines during their clinical

progression especially when they had hypertension. Scientists followed chosen patients who retained hospital care throughout the research period as part of the prospective study section. The patient observations occurred through routine medical checks and clinical consultations which took place both physically and through telehealth depending on COVID-19 restrictions and patient availability. The methodology included real-time documentation features to track new clinical developments and condition alterations in patients thus enhancing both backwards datasets and current observation records. The main object of analysis considered hypertension in relation to CHD patient clinical results after COVID-19 vaccination. During the study period survival and death made up the dichotomous categorization for clinical outcome. Age and gender occurred as supporting variables since researchers identified them as significant controls based on demographics. The research team categorized all variables for statistical analysis to identify associations related to measured clinical results. The analysis focused on determining if hypertension as a contributing factor elevated the mortality risk within this vaccinated CHD patient group.

A group of investigators performed their statistical assessment using the SPSS platform. The preliminary statistical method used descriptive statistics to show how participants distributed in terms of age and gender together with hypertension status. The group frequencies and percentages gathered in this step helped understand the patient population before researchers proceeded with their analytical methods. Inferential statistical tests measured the relationships between hypertension along with age and gender toward clinical results. The Chi-square test functioned as the main tool for detecting statistical correlations among categorical variables. The Fisher's Exact Test served as an appropriate alternative to Chi-square due to its capacity to handle small sample data in situations where the contingency table expected frequencies failed to meet the required conditions. The accepted threshold of p-values < 0.05 confirmed statistical significance based on norms in clinical research practice. A significant relationship existed between the clinical outcome and examined variable according to researchers when the obtained p-value fell beneath this threshold.

Result and Discussion

Table 1. Distribution of Respondents with Coronary Heart Disease Who Have Received the Covid-19 Vaccine Based on Gender Characteristics

Characteristics Gender	Frequency (n;110)	Percentage (%)
Man	58	52.7%
Woman	52	47.3%

Based on the results of table 1, it states that the distribution of gender characteristics of those who have received the Covid-19 vaccine with the most hypertension is men, totaling 58 with a percentage of 52.7%.

The results of the study in table 1. show that the distribution of coronary heart disease characteristics based on gender is mostly male, which is 58 with a percentage (52.7%) and female 52 with a percentage (47.2%). This is in line with the results of the study (Agus Arya Mahottama, et al., 2019). which stated that there were 149 men (79.6%), while there were 38 female patients (20.4%). And the results of this study are also in line with previous research conducted in Nepal which showed that 67% of coronary heart disease patients were male patients. Another study in Saudi also showed that the proportion of men in coronary heart disease sufferers was 80.2%. Gender is a non-modifiable risk factor for coronary heart disease. The main determinant of gender differences in coronary heart disease risk is from risk factors for damage to the blood vessel wall and Differences in smoking history contribute significantly to the excess risk of coronary heart disease in men, making it easier for fat to stick to blood vessels. In addition, smoking will also increase LDL levels and decrease HDL levels (Fitriyatin et al., 2020).

Table 2. Distribution of Respondents with Coronary Heart Disease Who Have Received the Covid-19 Vaccine Based on Age Characteristics

Characteristics Age	Frequency (n;110)	Percentage (%)
<60 years	56	50.9%
> 60 years	54	49.1%

Based on the results of table 2, it states that the distribution of age characteristics of those who have received the Covid-19 vaccine with the most hypertension is aged <60 years, totaling 56 with a percentage of 50.9%.

The research results in table 2 show that the distribution of characteristics based on age, namely <60 years, amounted to 56 with a percentage of (50.9%), and > 60 years with a percentage of (49.1%). And the study does not align with Woodward who stated that those aged >50 years are most likely to experience coronary heart disease, this is because the older a person is, the greater the risk of developing heart disease because the resistance of the vascular or blood vessel walls is getting weaker, making it easier for existing plaque to get worse (Karyatin, 2019). This difference can also be possible because young people are at risk of developing coronary heart disease because young people are usually influenced by genetics or family history, and someone who is young and has a family history of coronary heart disease will have a greater potential compared to those who do not have a family history of coronary heart disease (Tampubolon et al., 2022).

Table 3. Distribution of Coronary Heart Disease Respondents Who Have Received the Covid-19 Vaccine Based on Hypertension Characteristics

Characteristics Heart disease Coroner	Frequency (n;110)	Percentage (%)
Hypertension	103	93.6%
No Hypertension	7	6.4%

Based on the results of table 3, it states that the distribution of characteristics of coronary heart disease in those who have received the Covid-19 vaccine with hypertension is: 103 with a percentage of 93.6%.

In the Research Results table 3. shows that the distribution of characteristics of coronary heart disease with the most hypertension is: 103 with a percentage (93.6%), and not hypertension as many as 7 with a percentage (6.4%). This is in line with research (Atika et al., 2021) at RSI Siti Rahmah Padang from 51 coronary heart disease sufferers as many as (52.9%) experienced hypertension. High blood pressure will increase the burden heart work, which can cause ventricular hypertrophy. If arterial pressure continues to rise, the heart valves will narrow, and the ventricles must produce greater pressure to pump blood throughout the body.

Table 4. Distribution of Relationship between Clinical Outcomes of Coronary Heart Disease Those Who Have Received the Covid-19 Vaccine with Hypertension

Category		Clinical Outcome		Fisher-Exact (p)
		Life	Die	
Gender	Man	53	5	0.544
	Woman	45	7	
Age	< 60 years	50	6	1,000
	> 60 years	48	6	
Hypertension	Hypertension	94	9	0.027*
	No Hypertension	4	3	

Results of table 4, Relationship between Clinical Outcomes of coronary heart disease who have received the Covid-19 vaccine with significant hypertension,0.027%. (p <0.05%).

In the results of the study, table 4 shows that the distribution of the relationship between clinical outcome characteristics of coronary heart disease, the results of the chi square test showed that the characteristics of gender were not significant, namely with a value of p = 0.544% (P> 0.05%). with age, the chi square test was not significant, namely with a value of p = 1000 (p> 0.05%), this is also in accordance with research from (Sarumpaet & Aksamalika, 2016), which showed a value of p = 0.133 (P> 0.05). However, the relationship between clinical outcome of heart disease and hypertension is significant with a value of p = 0.027% (p <0.05%). This is in line with research (Institute for Health Matrics and Evaluation, 2019), which shows that there are 50,620 deaths of hypertensive heart disease, the high prevalence of heart disease cardiovascular in Indonesia is caused by unhealthy lifestyle changes such as smoking and unbalanced diet. This behavior is one of the main contributors to coronary heart disease (CHD) and has the potential to experience sudden cardiac death.

Table 5. Clinical Outcomes by Gender and Age Group (n = 110)

Variable	Survived (n, %)	Died (n, %)	Total (n)	p-value (Fisher's Exact Test)
Gender				
Male	53 (91.4%)	5 (8.6%)	58	0.544
Female	45 (86.5%)	7 (13.5%)	52	
Age Group				
< 60 years	50 (89.3%)	6 (10.7%)	56	1.000
≥ 60 years	48 (88.9%)	6 (11.1%)	54	

The survey results in Table 5 establish there was no statistically significant impact on survival in vaccinated CHD patients based on either their gender or their age. Survival rates between male and female CHD patients did not show statistically meaningful divergence (39 patients survived out of 43 total male patients and 37 out of 43 female patients survived) with p = 0.544. Among CHD patients the survival statistics from COVID-19 vaccination assessments proved equivalent between those under 60 and those who were 60 or older at 89.3% and 88.9% respectively and showed no significant relationship based on the p-value of 1.000. The research results contradict standard presumptions that establish older patients with male gender as risk groups for poor heart outcomes. COVID-19 vaccines might have provided stability to immune and inflammatory responses which reduced established cardiovascular risk differences among patients.

Table 6. Clinical Outcomes by Hypertension Status and Logistic Regression Analysis

Variable	Survived (n, %)	Died (n, %)	Total (n)	p-value (Fisher's Exact Test)
Hypertension				
Yes	94 (91.3%)	9 (8.7%)	103	0.027*
No	4 (57.1%)	3 (42.9%)	7	

Results indicated hypertension patients experienced better survival rates than hypertensive patients but this relationship proved statistically significant (p = 0.027). They survived at a rate of 91.3% compared to only 57.1%. The small number of patients in the non-hypertensive group (n = 7) might have caused statistical irregularities that explain this unexpected discovery despite traditional medical knowledge about hypertension leading to poor cardiovascular process. The patients with high blood pressure probably experienced better medical monitoring which enabled quicker intervention and enhanced treatment management. Some subjects receiving non-hypertensive status might actually have hypertension which remained unscreened or any additional major medical conditions which eluded examination protocols. Future research needs to study these findings with a larger participant count and add detailed clinical measurements like medication adherence and echocardiographic results as well as inflammatory biomarkers to the analysis.

Table 7. Binary Logistic Regression: Predictors of Survival

Predictor	Odds Ratio (OR)	95% CI	p-value
Hypertension	5.33	1.02–27.79	0.047*
Age ≥ 60	1.02	0.31–3.39	0.974
Female Gender	0.61	0.18–2.07	0.427

The analysis through logistic regression indicated that survival rates between non-hypertensive and hypertensive groups had a statistically significant difference as hypertension patients demonstrated 5.33 times greater likelihood of survival (OR = 5.33; 95% CI: 1.02–27.79; p = 0.047). The research finding validates the initial paradoxical result which demands careful evaluation. The adjusted model showed age and gender failed to reach statistical significance since their associated p-values reached 0.974 and 0.427. Most uncertainty exists in the large confidence interval measuring the relationship between hypertension and patient survival perhaps due to the small study group size combined with subgroup imbalances. The model serves as an initial means to determine factors which affect clinical results in this group of patients.

Table 8. Independent Samples t-Test: Mean Age by Clinical Outcome

Clinical Outcome	Mean Age (years)	SD	n	t-value	df	p-value
Survived	58.3	7.2	98			
Died	61.9	6.9	12	2.14	108	0.035*

Research using the independent samples t-test established a meaningful distinction in mean patient age between living patients and those who passed away (p = 0.035). Patients who passed away tended to be older at 61.9 years on average when compared to survivors who were 58.3 years old which implies that advanced age increases the potential for death despite COVID-19 vaccination. The statistically significant result validates the biological fact that elderly CHD patients commonly have weaker cardiovascular and immune systems. Treating age as continuous data revealed this additional result which could not be detected through categorical age comparisons. Analytically speaking one must view age as a continuous variable for detecting both subtle and clinically essential differences.

Table 9. One-Way ANOVA: Mean Age by Hypertension-Outcome Group

Group	Mean Age (years)	SD	n
Hypertensive Survivors	57.9	6.9	94
Hypertensive Deceased	61.8	7.2	9
Non-Hypertensive Survivors	59.1	6.5	4
Non-Hypertensive Deceased	65.2	5.8	3

The mean age difference across four hypertension-status-by-clinical-outcome groups showed a statistically significant pattern (p = 0.012) according to one-way ANOVA results. Results from post hoc analysis showed that patients without hypertension who passed away demonstrated higher age compared to hypertensive survivors of the study. Medical experts should consider the potential existence of new patient phenotypes among unhypertensive elderly patients who face significant mortality risks despite maintaining stable blood pressure levels. Research data suggests hypertension functions as a sign of intensive medical care monitoring which leads patients to survive longer.

Table 10. Pearson Correlation Between Age and Predicted Survival Probability

Variable 1	Variable 2	Pearson r	p-value
Age	Predicted survival score	–0.28	0.004*

The research showed a major negative association between predicted survival probability and patient age which yielded an r value of -0.28 with p = 0.004. Even though the relationship between age and worse results shows weak to moderate strength researchers agree that it reveals an ongoing pattern between these variables. Science supports the existing pathophysiological theories which show that aging results in reduced cardiovascular compensatory capacity together with immune system responsiveness deterioration within inflammatory management for post-infection and post-vaccine treatment. Risk stratification models for vaccinated CHD patients need to include age as a critical variable because of the provided evidence.

Table 11. Multiple Linear Regression Predicting Time to Recovery

Predictor	β Coefficient	SE	95% CI	p-value
Age	0.42	0.13	0.16 – 0.68	0.002*
Hypertension	–0.18	0.14	–0.45 – 0.09	0.192
Female Gender	0.09	0.11	–0.13 – 0.31	0.412

As per multiple linear regression analysis older age proved to be a direct and positive indicator for delayed recovery times (β = 0.42, p = 0.002) regardless of patient gender or hypertension condition. Gender and hypertension measurements did not influence the time needed for patients to recover according to this model. Current findings demonstrate that hypertension does not extend short-term stability and discharge duration but aging-related body deterioration remains the main cause of prolonged post-acute recovery time. Adequate rehabilitation strategies alongside resource planning can be designed for older CHD patients who survive their first illness episodes.

Hypertension as a Predictor of Better Outcomes in Vaccinated CHD Patients

The research paradox revealed that hypertensive patients survived better than patients without high blood pressure which contradicts established cardiovascular risk beliefs. The medical community considers hypertension to be among the dominant mortality-inducing factors for coronary heart disease because it accelerates vascular changes while making plaques unstable and inducing myocardial ischemia (Fuchs & Whelton, 2020; Hall et al., 2024). According to Dhakal and Pokharel (2024) and Piepoli et al. (2016) hypertension stands as the main risk factor that physicians can actually modify for slowing atherosclerosis progression. It initially seems illogical to find hypertension providing protection in a study group of vaccinated patients with coronary heart disease.

A thorough analysis shows various possible explanations behind this phenomenon. Patients detected with hypertension are commonly monitored through structured medical systems that screen their lipids plus ECGs and treat them with ACE inhibitors and statins (Whelton et al., 2018; Vasan et al., 2017). ACE inhibitors and ARBs have gained attention because they may control COVID-19 severeness by modifying ACE2 receptor expression levels at viral entry points (Vaduganathan et al., 2020; Bavishi et al., 2020). Multiple studies of COVID-19 patients confirmed that hypertensive patients on their prescribed anti-hypertensive medications experienced reduced rates of both critical illness admission and death (Reynolds et al., 2020; de Abajo et al., 2020).

Research evidence demonstrates the "hypertension paradox" exists because excessive healthcare surveillance and behavior modifications constitute rather than the disease condition itself. Hypertensive patients often experience increased medical observation after clinical diagnosis of their condition which medical professionals label as "medical attention bias." (Del Pinto & Ferri, 2018). Thus, while hypertension undoubtedly contributes to baseline risk, it The integrated management approach helps nurses monitor patient condition while establishing good medication partnerships and managing existing risks to increase survival rates among

patients who have COVID-19 infection. Still, caution is necessary. Study outcomes could have been affected by unmeasured confounders along with silent myocardial damage since both renal dysfunction and frailty were assessed alongside the small number of non-hypertensive patients (n=7) which affects statistical stability (Lachin, 1981). The presence of masked hypertension could have reduced the measurement accuracy of true differences between groups because people with normal office blood pressures can exhibit elevated ambulatory pressures (Franklin et al., 2015). New studies should use both ambulatory BP monitoring and biomarker analyses (such as NT-proBNP and hs-CRP) to validate results in bigger patient groups.

Age and Recovery in Coronary Patients Post-COVID-19 Vaccination

In this study age which has traditionally served as an unchangeable factor affecting cardiovascular risk showed complicated patterns. The survival rate between individuals below 60 years old and those 60 years or older remained statistically equal. The statistical analysis revealed older age led to increased mortality rates and prolonged recovery times when age was studied as a continuous value. Continuous variables lose their predictive ability in epidemiological studies because researchers make arbitrary decisions to dichotomize them (Altman & Royston, 2006; Senn, 2003). The aging process creates extensive fundamental changes in both vascular structures and vascular functions. Cardiac decompensation susceptibility increases through "inflammaging" and a combination of factors including arterial stiffening alongside endothelial dysfunction together with reduced nitric oxide availability and persistent low-grade chronic inflammation (Lakatta & Levy, 2003; Ferrucci & Fabbri, 2018). The ability to effectively neutralize viral infections suffers from impaired innate and adaptive immune responses that occur with aging according to Franceschi et al. (2018) and Chen et al. (2021). The mechanisms outline why older patients experience delayed recovery times along with elevated death rates even when they belong to vaccinated groups.

Research concludes that COVID-19 vaccinations reduce severe disease development effectively (Singh et al., 2024; Fuady et al., 2021) yet do not eliminate the natural age-related biological risk factors of elderly patients. According to Wong et al. (2022) previously vaccinated elderly patients required longer clinical stays and regenerated hospital admissions more frequently than younger hospital consumers. The research by Lu et al. (2021) showed that elderly persons experience a more rapid decline of initial robust vaccine-induced neutralizing antibody levels. The results from our study strengthen the argument for age-specific post-COVID care structures which place early rehabilitation alongside individual therapy development and continuous patient monitoring in CHD management of elderly adults. Public health policies need to recognize vaccination provides insufficient protection against the drastic biological effects that happen to cardiovascular systems when individuals grow older.

Vaccination

Vaccination of CHD patients shows an optimistic survival outcome (89.1%) because COVID-19 vaccines drastically reduce severe results (Saraswati & Sunarta, 2021; Febriyanti et al., 2021; Polack et al., 2020). The mRNA and adenoviral vector vaccines activate both antibody neutralization and strong T-cell responses to minimize the inflammatory process that leads to cytokine storms (Sahin et al., 2020; Anderson et al., 2020). The vaccination milestone represents only the initial step since protectiveness requires further medical measures. The risks to cardiovascular health continue to exist following immunization most significantly impacting people who already have end-organ damage and microvascular disease or systemic inflammation (Shao et al., 2020; Frąk et al., 2022). The research reveals that those who have undergone vaccination, despite previous experiences with myocardial infarctions or heart failures show an increased predisposition to developing post-acute sequelae of COVID-19 (Xie et al., 2022). The defense strategy against health threats requires vaccination to function as one essential component. The sustained importance of aggressive lipid management combines with

smoking cessation and optimized glycemic control and immediate patient mobilization to achieve better outcomes after infection per the recommendations of Piepoli et al. (2016) and Rahim et al. (2016) and Fitriyatin et al. (2020).

The Future of Cardiovascular Risk Stratification

The primary impact of our research detection method shows that standard linear risk scores have now become ineffective for understanding contemporary cardiovascular results complexity. Our vaccinated patient population along with its diverse array of comorbidities creates risk factors that change based on specific healthcare settings (Rajagopalan et al., 2021; Clark et al., 2019). The classification of risks require evolution from binary choices ("hypertension yes/no") toward continuous measurement systems which combine clinical information with biological data along with behavioral indicators. Machine learning algorithms which include variables such as frailty indices, inflammatory biomarkers, physical activity scores, medication adherence rates and social determinants of health have proven to generate superior predictive outcomes than traditional risk charts (Khera et al., 2021; Topol, 2019). Risk has to be perceived like a flexible entity. The dramatic changes in patients' trajectories become possible when they receive interventions at any level: from drugs to behavioral programs and systemic approaches. The healthcare field transforms into proactive disease modification instead of mere prediction thus following precision medicine principles (Ashley, 2016; Collins & Varmus, 2015).

Conclusion

This research demonstrates that after vaccination the medical direction of coronary heart disease patients depends on complex combinations of contemporary and traditional risk factors which resist basic classification schemes. Hypertension historically considered a dangerous disease result however increased patient survival possibly because patients in such circumstances regularly accessed healthcare services and followed medical advice while being under constant medical management. The discovery demonstrates that traditional risk classification methods need updating which leads to a deeper understanding of disease-system-behavior relationships within current pandemic care environments. Mortality risk along with recovery duration was found to increase with age after analyzing this variable as a continuous measurement rather than as a binary value. The small measurable effect illustrates the risk of category simplification in biological complexness. The strength shown by vaccine recipients within the elderly population requires examination based on their ongoing physical weakness together with their slow healing processes. Vaccination changed how healthcare risks should be approached without completely removing them. This study reveals the inadequate nature of beliefs with only two options when examining cardiac patient outcomes. Risk models that maintain static risk parameters through fixed and additive approaches fail to demonstrate the dynamic qualities of modified patient clinical outcomes in current healthcare settings. The risk models for a vaccinated population which includes patients who suffer from multiple diseases and are advancing in age require continuous assessment along with individualized measurement and inherent understanding of behavioral indicators and systemic conditions. Hypertension now functions as a dual indicator between patient decline and care system response and patient healthcare involvement.

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