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Cardiovascular Disease Risk after COVID-19 in Diabetic and Non-Diabetic Adults: A Study in Iraq : Risiko Penyakit Kardiovaskular Pasca COVID-19 pada Orang Dewasa Penderita Diabetes dan Non-Diabetes: Sebuah Studi di Irak

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Abstract

General Background: COVID-19 has emerged as a global health crisis with significant implications for patients with underlying cardiovascular conditions. **Specific Background:** Increasing evidence indicates that cardiovascular disease is associated with severe outcomes and complications in infected individuals. **Knowledge Gap:** Despite numerous studies, there remains a need to synthesize findings on cardiovascular risks and outcomes in diverse populations. **Aims:** This study aims to analyze the relationship between COVID-19 and cardiovascular disease, focusing on risk factors, clinical manifestations, and outcomes. **Results:** The findings indicate that patients with pre-existing cardiovascular conditions are more likely to experience severe disease, higher mortality, and long-term complications. **Novelty:** The study consolidates evidence from multiple studies to provide a comprehensive overview of cardiovascular risks in COVID-19 patients. **Implications:** These findings support the need for targeted clinical management and preventive strategies for vulnerable populations, contributing to improved healthcare planning and patient care.

Keywords: Covid-19, Cardiovascular Disease, Clinical Outcomes, Risk Factors, Mortality

Key Findings Highlights

- Pre-existing conditions are associated with severe cases and complications
- Multiple studies report elevated mortality among affected patient groups
- Long-term health issues remain a significant concern after infection

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Introduction

1. Background and Rationale

COVID-19, Caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the coronavirus disease 2019 (COVID-19) pandemic has presented the world with the most significant challenges in the health system in the history of mankind, with over 770 million reported cases and **6.9 million** reported fatalities [1]. Although the first concern has been the acute respiratory illness, new evidence shows that COVID-19 has major extrapulmonary consequences, specifically on the cardiovascular system, both acutely and in the post-acute or long COVID phase. **Long COVID** is the continuation or the development of symptoms and organ dysfunction, which occurs more than four weeks after the first infection across different organ systems, such as the heart and vasculature. New cohort research has provided evidence that the population of adults who have recovered due to COVID-19 develops higher risks of significant cardiovascular events, such as myocardial infarction, heart failure, arrhythmias, stroke, and thromboembolic complications, with rates of 10-30% depending on pre-existing risk factors and the severity of the infection [2,3].

Diabetes mellitus has become a high-risk factor of post-COVID cardiovascular risks. Diabetic patients are likely to have chronic low-grade inflammation, endothelial dysfunction, and metabolic derangements that predispose them to vascular complications. According to the evidence of big-data studies, adults with diabetes recovered after COVID-19 receive 1.5- to 2-fold more cardiovascular events than non-diabetic people, even after the age, sex, and comorbidities were adjusted [4,1]. The fact that COVID-19 itself causes inflammatory cytokine storms, oxidative stress, and coagulopathy contributes to this increased susceptibility [5,6].

The United Kingdom and the United States have shown a longitudinal effect of the cardiovascular effect of COVID-19. As an example, a cohort of the UK, which was based on a population, reported that the post-acute COVID-19 patients had a 1.6-fold increase in the risk of major adverse cardiovascular events within 12 months (including myocardial infarction (5.2% of cases), stroke (4.1%), and arrhythmias (6.3%)) compared to the matched controls who did not have any COVID-19 [3]. Also, data provided by the United States Department of Veterans Affairs revealed that patients with post-COVID incidences of heart failure (HR 1.72), myocarditis (HR 2.10), and thromboembolic events (HR 1.48) were higher compared to non-infected patients, which is a worldwide finding showing that the long-term cardiovascular sequelae following SARS-CoV-2 infection [2].

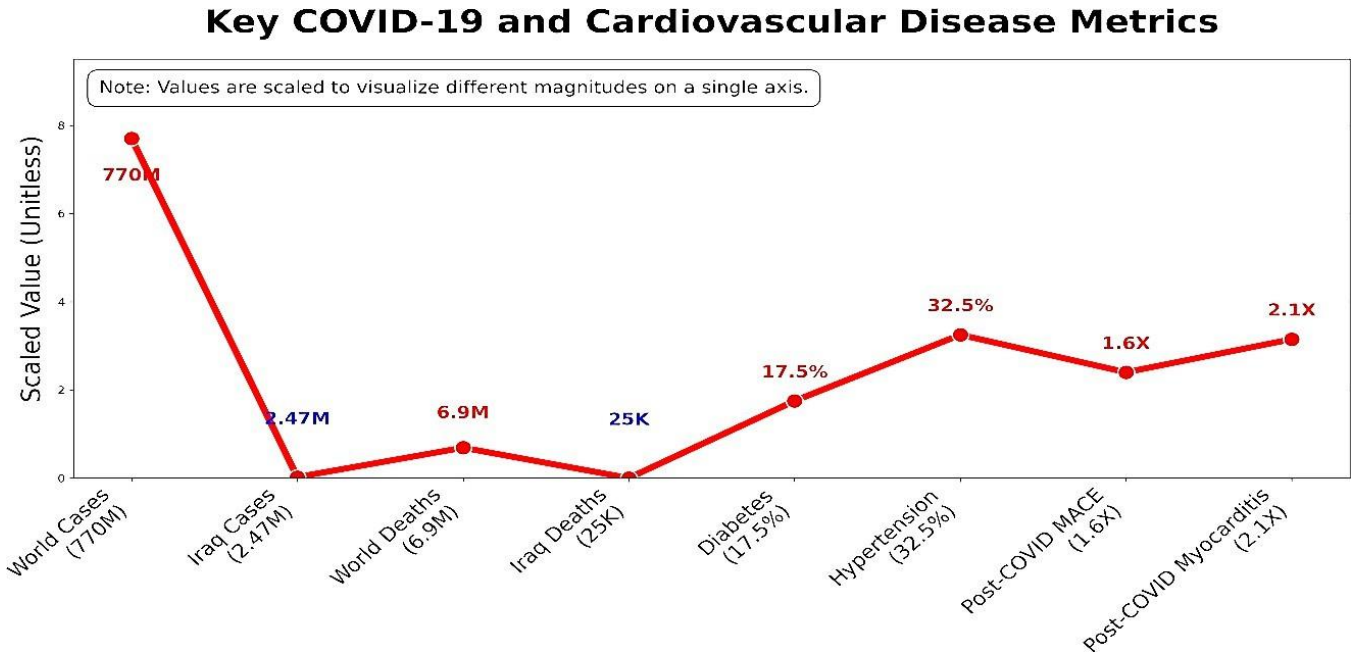

Figure 1. **Figure 1: Post Covid-19 Cardiovascular risk profile**

SARS-CoV-2 affects cardiovascular health, in part, through several pathways, which are mechanistically determined. The virus attaches to the angiotensin-converting enzyme 2 (ACE2) receptor, which is found in cardiac myocytes, vascular endothelium and pericytes, causing homeostasis of renin-angiotensin-aldosterone system (RAAS). It results in inflammation of the endothelium, microvascular thrombosis, inflammation of the myocardium, and arrhythmogenic predisposition [5,6]. These processes are worsened in diabetic patients by pre-existing endothelial dysfunction and poor glycemic regulation in patients, which accelerates the instability of the plaque and the probability of cardiovascular event following COVID-19 [4]. Hyperglycemia in acute infection is also linked to the up to 2.3-fold risk of myocardial injury, and glycemic control is also important to reduce cardiovascular risk after COVID [1].

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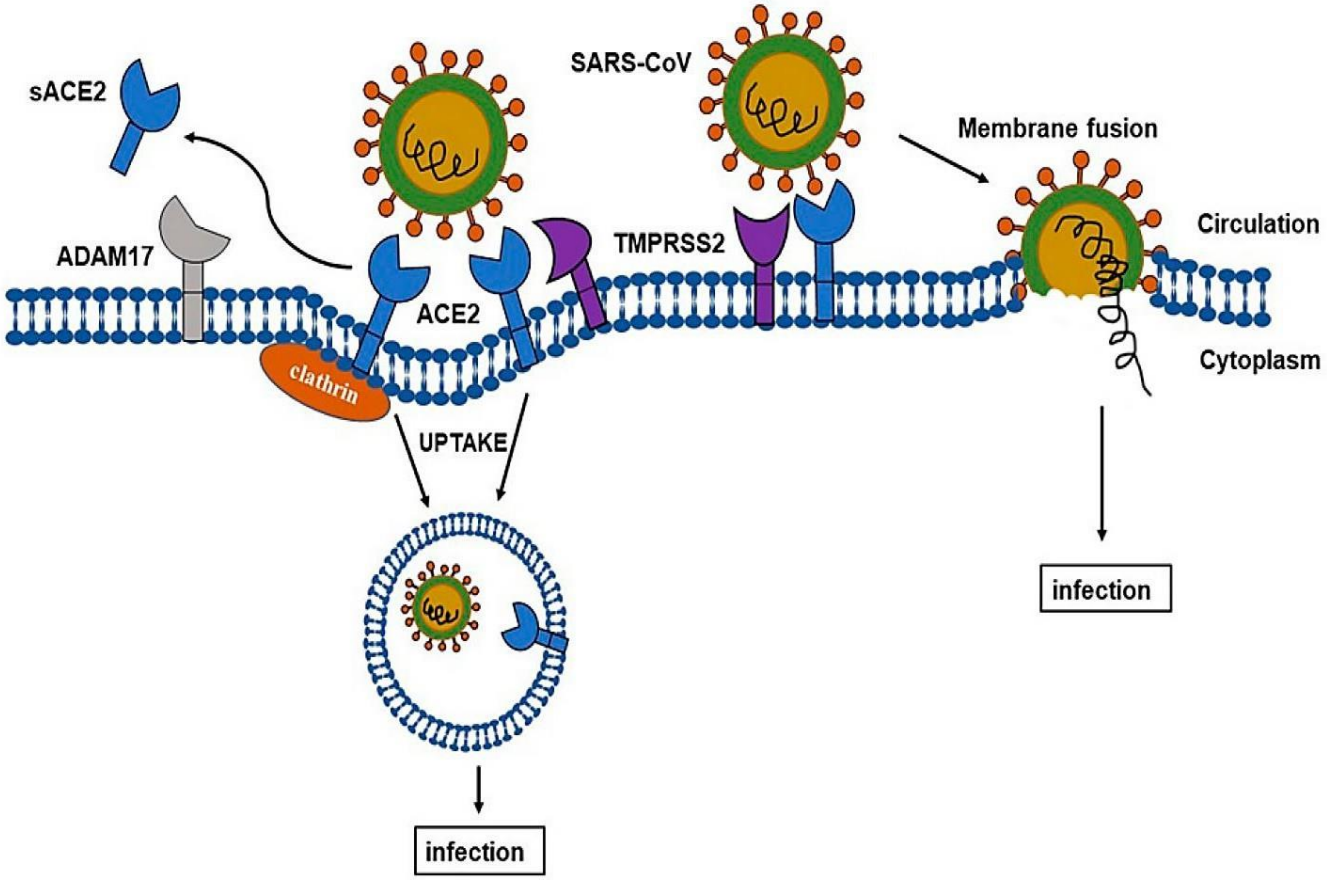

Figure 2. **Figure 2 : SARS-CoV-2 attaches to the angiotensin-converting enzyme 2 (ACE2) receptor, which is found in cardiac myocytes, vascular endothelium and pericytes , causing homeostasis of renin-angiotensin-aldosterone system (RAAS)**

The cardiovascular outcomes in diabetic and non-diabetic adults are investigated due to the differences in risks identified in previous studies. Koyama et al. [4] found that, in adults ≥18 years, 28.4% of diabetics and 15.1% of non-diabetics experienced cardiovascular events in 12 months, which impacted the use of pre-existing metabolic disorders in the pathophysiology of long COVID. Such results support the importance of stratified public health measures, which should focus on high-risk groups, especially in low- and middle-income countries like Iraq, where the access to healthcare and its follow-up care are limited.

Furthermore, the sub-clinical myocardial injury persistence as assessed by cardiac biomarkers and imaging techniques implies that the risk of cardiovascular events goes beyond clinical events. Research shows that at least 30 percent of post-COVID patients without recent CVD have an elevated troponin level, ECG abnormalities, or lower left ventricular ejection fraction, which is a sign of silent but clinically significant cardiovascular dysfunction [5,6]. This supports the need to actively monitor by providing follow-up visits in a structured way, echocardiography, and laboratory evaluation of the metabolic and inflammatory markers, especially in high-risk populations.

To conclude, COVID-19 is not only an acute infectious danger but also a trigger of cardiovascular morbidity in the long-term. The patients with diabetes are disproportionately impacted as almost twice the risk of cardiovascular events after COVID occurs in adults compared to non- diabetic patients. The mediating factors of this increased risk are inflammation, endothelial injury, coagulopathy, and underlying metabolic derangements. The high rates of diabetes, hypertension, and scarce healthcare facilities in Iraq and the Middle East region, in general, contribute to the urgency of the systematic investigation, prevention, and management of the post-COVID cardiovascular complications. Taken together, these facts support the focus of the present research on the possible evaluation and comparison of cardiovascular outcomes in diabetic and non- diabetic adults with post-COVID-19 recovery with the aim of informing clinical practice and population health policy in the context of the Iraqi population [1-4,7].

1.2 Problem Statement

Although the world is becoming more aware of the post-COVID cardiovascular complications, the evidence of the Middle East countries and especially Iraq is minimal as the presence of chronic metabolic diseases, including diabetes and

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hypertension, is widespread. In Iraq, the prevalence of diabetes is about 1520% among adults, and 3035% have high blood pressure, which are all known risk factors of cardiovascular disease [7]. Similar to other Iraqi regions, the Wasit Governorate also had several COVID-19 waves in 2021-2023, and the healthcare services were overloaded, resulting in the possibility of delays in managing chronic diseases and following up with post-COVID measures. The existing literature is mostly based on North America, Europe, and East Asia where access to healthcare, diagnostics and post- COVID monitoring are much different than those in Iraq. It is a critical gap in the knowledge of the long-term cardiovascular risks of COVID-19 in Iraqi adults, especially between diabetic and non-diabetic samples. This gap is a critical problem to address in the context of evidence-based policy-making, focused clinical intervention, and resource deployment in Iraqi health care systems.

1.3 Aim of the study and its objective.

The main objective of the present research is to assess the risk of cardiovascular disease (CVD) after the COVID-19 infection in the adult population of Iraq and, in particular, to compare the results of diabetic and non-diabetic groups. The research aims at measuring the rate of post- COVID cardiovascular incidents, the key predictors, such as age, sex, comorbidities, and COVID-19 severity, and the protective effect of vaccination. The proposed research aims to offer practical implications to clinical management and community health interventions in Iraq, where post-COVID cardiovascular surveillance is underdeveloped by creating a clear risk profile.

1.4 Research Specific questions and Hypotheses.

The research questions proposed in the study based on the available dataset of 1,000 adults (500 diabetics and 500 non-diabetics) in the Al- Karama and Al-Zahraa Teaching Hospitals in Wasit are as follows:

1. *What are the general cardiovascular events 12 months after recovery after COVID-19 among adults in Wasit , Iraq?*
2. *Is pre-existing diabetes a risk factor of post-COVID cardiovascular disease as compared to non-diabetic individuals?*
3. *What is the impact of other determinants (age, sex, hypertension, dyslipidemia, chronic kidney disease, body mass index, smoking status and severity of COVID-19) on post-COVID CVD risk?*
4. *How does the COVID-19 vaccination affect the risk of post-COVID cardiovascular events reduction?*

Based on these questions, direct hypotheses were developed based on the study data:

- **H1**: The post-COVID cardiovascular disease among adults with diabetes is more common than it is among non-diabetic adults (hypothesized 29.6% vs 13.2%).
- **H2**: Severe COVID-19 infection is connected with post-COVID cardiovascular events at risk.
- **H3**: The independent predictors of post-COVID CVD are old age (age 60 and above) and comorbid conditions hypertension, dyslipidemia, and chronic kidney disease.
- **H4**: The risk of post-COVID cardiovascular problems due to the COVID-19 vaccination is lower, and the hazard ratio is expected to be about 0.65.

These hypotheses are directly based on preliminary data indicating the dissimilar incidence of CVD events in subgroups and enable the study to statistically test the connections between diabetes, other comorbid conditions, vaccination, and post-COVID cardiovascular results in the Iraqi setting.

1.5 Study Significance

The paper has a large clinical, policy, and population health implication in Iraq, especially the Wasit Governorate that witnessed several COVID-19 outbreaks in 2021-23. In clinical terms, the recognition of post-COVID cardiovascular disease (CVD) incidence and predictors in adults, including the high-risk group of diabetics, allows the timely screening and prevention of the disease. As an illustration, initial evidence shows that 29.6% of diabetic adults had at least one CVD event 12 months after COVID-19 recovery, compared to 13.2% of non-diabetic adults, which is why a systematic follow-up and management approach is critically needed [2,4]. Policymaking wise, the results will help justify the creation of the post-COVID care programs in the Iraqi hospitals and community clinics to guide the resource planning of cardiology, endocrinology, and internal medicine services. The protective effect of vaccination (HR = 0.65) is also observed, which again highlights the necessity of conducting public health campaigns to increase the rates of vaccine uptake among high-risk groups, such as older adults over 60 and comorbid patients [3].

There are implications of the health of the population in terms of long-term cardiovascular follow-up. Morbidity and health care burden can be lowered, rehabilitation plans can be determined in order to direct national guidelines, by creating systematic follow-up of recovered COVID-19 patients, especially diabetics. Altogether, the research fills a crucial gap in evidence and offers evidence-based suggestions to improve patient outcomes and decrease post-COVID cardiovascular complications in Iraq [5-7].

1.6 Scope and Delimitations

The participants of the study are the adults aged 18 years and older diagnosed with COVID-19 between January 2021 and December 2023 and referred to Al-Karama and Al-Zahraa Teaching Hospitals in Wasit Governorate, Iraq. Only those patients who have been confirmed with COVID-19 through PCR testing were involved and those with incomplete medical records or already underwent cardiovascular interventions before COVID-19 were excluded. The study will include the comparison of diabetic (N=500) and non-diabetic (N=500) adults and the evaluation of the occurrence of post-COVID cardiovascular events during 12 months of follow-up and assessed with structured visits at 3, 6, and 12 months.

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Limitations consist of a geographic limitation to the Wasit Governorate, which might make it hard to generalize to other areas of Iraq that might have a different healthcare infrastructure or demographic makeup. Moreover, despite the fact that the study includes significant comorbidities, including hypertension, dyslipidemia, and chronic kidney disease, other unmeasured variables, such as lifestyle choices or adherence to medication, can determine post-COVID results. The timeframe is limited to three years of COVID-19 cases as it represents local pandemic waves and vaccine rollout schedules.

1.7 Operational Definitions and Key Terms

To ensure clarity and consistency, a number of the operational definitions were embraced in this study. The events related to cardiovascular disease (CVD) were observed to be either myocardial infarction (MI), heart failure, stroke, transient ischemic attack (TIA), arrhythmias, or myocarditis within the 12 months of the recovery after COVID-19. According to WHO, severe COVID-19 was defined as infection that needs hospital care, additional oxygen, or admission to intensive care unit (ICU). The definition of diabetes mellitus involved the presence of a previous diagnosis, 6.5 or above on HbA1c, or the use of anti-diabetic medications whereas the non-diabetic status was the individuals who had never had diabetes and whose values fell below 5.7.

The status of vaccination was noted as either unvaccinated, partially vaccinated (one dose), and fully vaccinated (two or more doses) and the effect of vaccination on CVD risk was measured. Hypertension (blood pressure 140/90 mmHg or antihypertensive use), dyslipidemia (elevated LDL cholesterol or lipid-lowering therapy), chronic kidney disease (eGFR less than 60 mL/min/1.73 m ²), and obesity were all comorbidities, which were operationalized as BMI 30kg/m 2. Covariates in regression models were other demographic factors like age, sex and smoking status.

2. Literature Review

2.1 Epidemiology of COVID-19 and Long-Term Sequelae

COVID-19 has had an impact on over **770 million people** across the globe, and significant morbidity is not limited to the acute infection period. Although the response to the pandemic in the first few months was mainly aimed at minimizing mortality, more and more data show that a substantial percentage of survivors have long-term symptoms and dysfunction of various organs, which is known as long COVID or post-acute sequelae of **SARS-CoV-2 infection** (**PASC**) [2]. The epidemiological researches indicate that 10-30 percent of adults have long- term complications of more than 12 weeks of continued infection, even with mild or moderate disease [3].

One of the most clinically important aspects of long COVID is cardiovascular involvement. The United States and European large cohort studies have found myocardial infarction, heart failure, arrhythmias, stroke, and thromboembolic risks to be higher in the post-infection period (12 months) than in non-infected controls [2]. According to one of the landmark studies that studied more than 150,000 COVID-19 survivors, the risk of cardiovascular events rose by an average of 5570, and the excess risk was the greatest in patients who had to be hospitalized or be put on intensive care [2].

Diabetes mellitus has always become a significant alteration of the post-COVID outcomes. Patients with adult diabetes have a 23-fold to 3-fold increased risk of severe COVID-19 in the acute phase and a high risk of cardiovascular mortality in the long-term after recovery [4]. Acute severity and delayed cardiovascular complications are caused by hyperglycemia, chronic inflammation, endothelial dysfunction, and prothrombotic conditions. According to epidemiological studies, the post-COVID cardiovascular events can be higher than 2530% in diabetics populations versus 1015% in non-diabetics, which is also reflected by the current cohort study [4].

Limited evidence on the subject indicates similar trends in regional data in the Middle East. The research on the populations in the Middle East has pointed to the high background prevalence of cardiovascular risk factors, including diabetes, hypertension, and obesity, which may increase the chronic effects of COVID-19 [7]. Underdiagnosis and delayed follow-up, especially in Iraq, where the effects of the healthcare disruption during the pandemic were acute, can further burden the post-COVID cardiovascular disease. According to WHO reports, those countries that have weak health systems have long-term disproportionate consequences because of the lack of rehabilitation and monitoring capacity of chronic diseases [1].

Vaccination has become one of the key modifying factors in long COVID epidemiology. According to population-based studies, the fully vaccinated people will develop long-term cardiovascular complications that are 30-40 times lower than among the unvaccinated individuals, even during breakthrough infections [3]. This is a protective effect that shows the significance of vaccination in the prevention of severe acute disease as well as in the prevention of long-term cardiovascular morbidity.

Altogether, epidemiological data show that COVID-19 has already ceased to be an acute infectious crisis; it has become a chronic health issue, and cardiovascular disease is one of the significant parts of the long-term sequelae. These results are the epidemiological basis of examining post-COVID cardiovascular outcomes among high-risk groups, including adults with diabetes, in underrepresented populations, including Iraq [2,7,8].

2.2 Pathophysiology Linking SARS-CoV-2 to Cardiovascular Injury

(Inflammation, Coagulopathy, and Endothelial Dysfunction)

Accumulating evidence confirms that the SARS-CoV-2 infection directly and indirectly impacts the cardiovascular system resulting in both acute injuries and cardiovascular sequelae. The multifactorial pathophysiology is based on the complex

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interaction of systemic inflammation, immune dysregulation, endothelial damage, and coagulation disorders that, when combined, justify the high prevalence of post-COVID-19 cardiovascular disease in various populations [6,9].

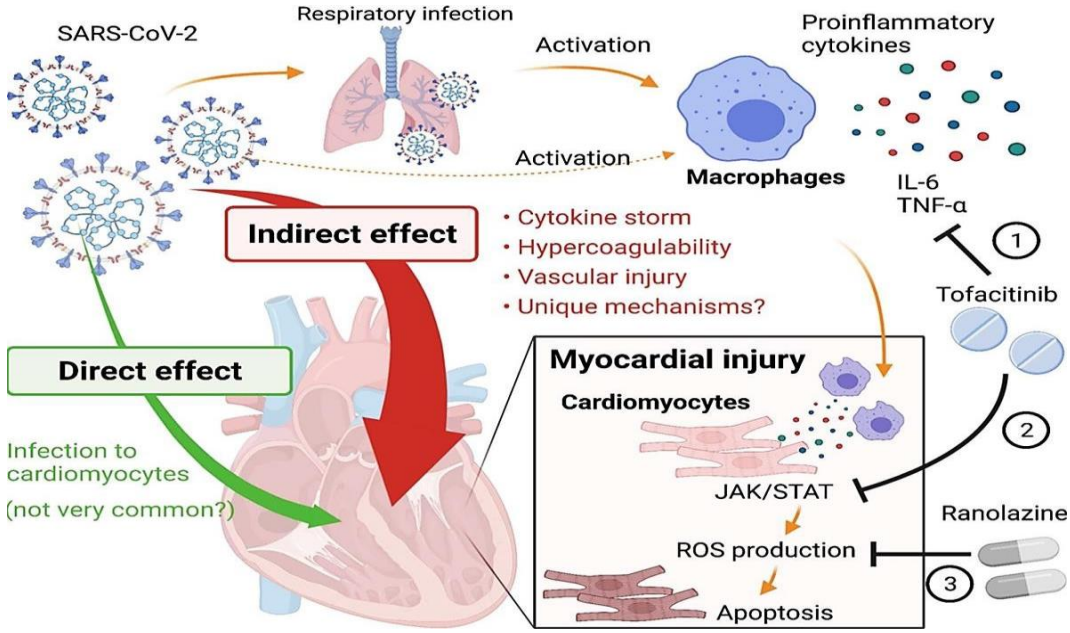

Figure 3. **Figure 3: Direct and indirect impacts the cardiovascular system resulting in both acute injuries and cardiovascular sequelae**

2.2.1 Systemic Inflammation and Cytokine-Mediated Cardiac Injury

Among the key processes that connect COVID-19 and cardiovascular injury, it is important to note exaggerated systemic inflammation, which is often referred to as a cytokine storm. SARS-CoV-2 infection causes the activation of both innate and adaptive immune responses with the resultant increase in the circulation of inflammatory mediators including interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-alpha), interleukin-1 beta (IL-1 beta), and C-reactive protein (CRP). It has been observed that the severity of COVID-19 correlates with a 2-5-fold increase in IL-6 levels in the patients, which is strongly associated with myocardial injury and poor cardiovascular outcomes [9].

Such inflammatory environment helps in myocardial depression, plaque instability and arrhythmogenesis. The inflammatory cytokines damage the myocardial contractility, cardiomyocytes calcium handling, and oxidative stress. The presence of myocardial edema, inflammatory infiltrates, and interstitial fibrosis has been identified by autopsy studies even in patients without a history of cardiovascular disease, which confirms the importance of inflammation-driven cardiac damage [6].

2.2.2 Direct Viral Effects and ACE2 Dysregulation

SARS-CoV-2 enters cells through the angiotensin-converting enzyme 2 (ACE2) receptor that is highly expressed on cardiomyocytes, vascular endothelial cells, and pericytes. ACE2 is downregulated during viral binding and internalization and this interferes with the renin angiotensin aldosterone system (RAAS). ACE2 loss leads to hyperstimulation of angiotensin II, which favors vasoconstriction, inflammation, oxidative stress, and myocardial fibrosis [9].

This RAAS imbalance leads to acute injury of myocardium and chronic cardiovascular remodelling. Angiotensin II overload increases vascular permeability and inflammatory cell infiltration, which further worsens the endothelium and predisposes to thrombosis. These processes are especially applicable to patients who already have pre-existing diabetes or hypertension, and their baseline ACE2 dysregulation is already elevated, increasing the cardiovascular effects of COVID-19.

2.2.3 Endothelial Dysfunction and Microvascular Injury

Endothelial dysfunction is a pillar of cardiovascular pathology of COVID-19. SARS-CoV-2 infects endothelial cells directly, resulting in endotheliitis, which is endothelial swelling, apoptosis, and deletion of antithrombotic properties. Clinical and pathological research has revealed extensive endothelial damage in pulmonary, coronary, cerebral and renal vascular beds [6].

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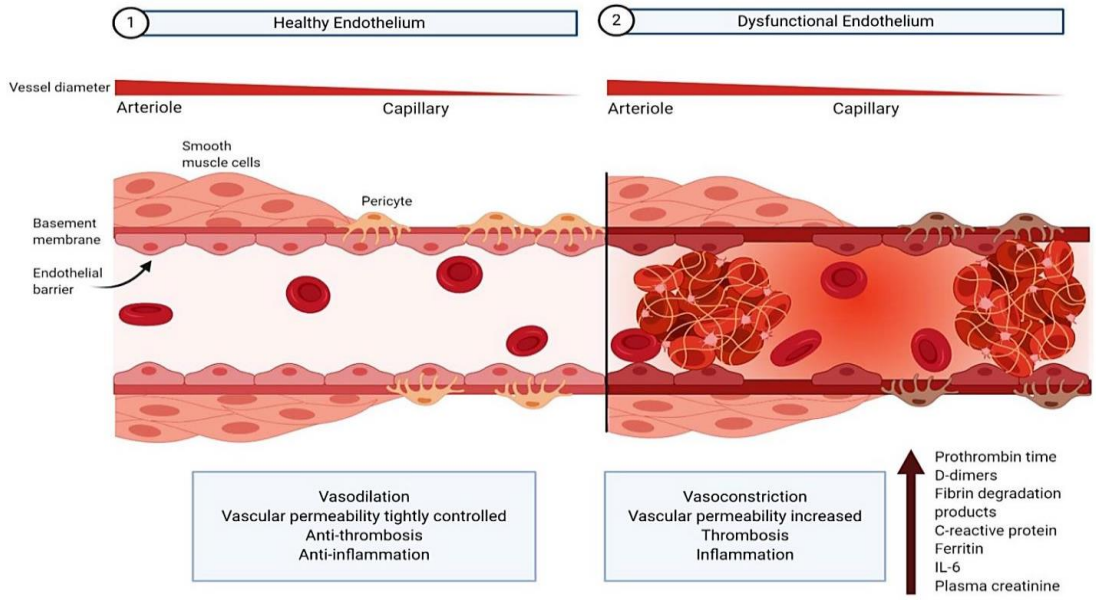

Figure 4. **Figure 4: Healthy Vs Dysfunction Endothelium**

2.2.4 COVID-19-Associated Coagulopathy and Thrombotic Risk

The other urgent mechanism is COVID-19-associated coagulopathy that significantly contributes to the risk of arterial and venous thrombotic events. Laboratory abnormalities including high levels of D-dimer, fibrinogen and factor VIII have been constantly reported especially in hospitalized patients. Thrombotic complication rates are estimated at 2030% in severe cases of COVID-19 in spite of anticoagulation prophylaxis [9].

COVID-19 causes hypercoagulability, which is caused by the activation of the coagulation cascade due to inflammation, platelet hyperreactivity, endothelial injury, and fibrinolysis impairment.

These processes describe the reported elevations in myocardial infarction, ischemic stroke, pulmonary embolism, and microthrombi development. Notably, thrombotic risk can be extended past the acute period, which leads to delayed cardiovascular outcomes during 6-12 months of follow-up as shown in large cohort studies [2].

2.2.5 Interaction with Metabolic Disorders and Diabetes

COVID-19 cardiovascular pathophysiology is greatly enhanced in diabetic mellitus. Chronic hyperglycemia facilitates endothelial dysfunction at the baseline, low-grade inflammation, oxidative stress, and a prothrombotic condition, which are all complementary to SARS-CoV-2-related damage. The COVID-19 has a greater inflammatory cytokine and coagulation profile in diabetic patients, which in part explains the 2-3 fold greater cardiovascular complications in this population [5].

Moreover, the compromised immune functions and changed ACE2 expression in diabetes can contribute to the retention and slow healing of tissues, which leads to a long-term cardiovascular risk. These processes are consistent with clinical findings of increased incidences of post- COVID myocardial infarction and heart failure in diabetic populations versus non-diabetics.

2.2.6 Long-Term Cardiovascular Sequelae

In combination, inflammation, endothelial dysfunction, and coagulopathy form a biological context of long-term cardiovascular outcomes of COVID-19 disease. Long-term studies have shown that the heart failure, arrhythmias, ischemic heart disease, and cerebrovascular events continue to increase during 12 months after infection even after controlling the traditional risk factors [2]. It is thought that persistent immune activation and microvascular damage are the cause of these delayed outcomes.

To conclude, SARS-CoV-2 causes cardiovascular damage, which is caused by interconnected inflammatory, endothelial, and thrombotic mechanisms. Such mechanisms are not only able to explain acute complications but also have a solid biological plausibility of explaining the high long-term cardiovascular risk in post-COVID populations, especially in individuals with diabetes and other cardiometabolic diseases [2,6,9].

2.3 Diabetes Mellitus as an Amplifier of Cardiovascular Disease Risk After COVID-19

Diabetes mellitus has been reestablished as an independent risk factor of cardiovascular disease (CVD) and has become one of the most significant clinical modifiers of post-SARS-CoV-2 infection outcomes. Chronic metabolic dysregulation, vascular injury, and immune impairment are the common features of both type 1 and type 2 diabetes, which in combination with cardiovascular effects of COVID-19 increases the severity of the disease. According to epidemiological data, the high incidence of severe COVID-19 and significantly elevated post- acute cardiovascular complications observed in people with

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diabetes are two to three times higher than in non-diabotic populations [2,5].

2.3.1 Poor Glycemic Control and Cardiovascular Vulnerability

The role of chronic hyperglycemia in increasing the cardiovascular vulnerability of diabetic patients is central. High glucose concentration encourages non-enzymatic glycation of proteins, oxidative stress, and pro-inflammatory signaling pathway. The lack of glycemic control (as demonstrated by the increase of HbA1c levels ≥7.0) has been linked to increased levels of endothelial dysfunction, arterial stiffness, and atherosclerotic plaque development. Hyperglycemia caused by stress during acute COVID-19 infection also contributes to metabolic instability, which results in acute myocardial injury and arrhythmias [6].

Clinical trials have shown that diabetic patients who are not under controlled glycemia levels have a significantly increased level of inflammatory markers including CRP and IL-6 which is associated with poor cardiovascular outcome. The risk of post-COVID cardiovascular events was about 30-40 percent higher in patients with HbA1c of 8.0 percent and above than in patients who had adequate glycemic control [2]. The implications of these findings are that metabolic regulation is imperative in reducing the risk of cardiovascular in the long term.

2.3.2 Microvascular and Macrovascular Disease as Pre-Existing Substrates

Microvascular and macrovascular complications of diabetes are pathologically predetermined as the pathological basis of COVID-19-related cardiovascular injury. Microvascular disease is an impact observed on small vessels serving the myocardium, kidney, retina, and nervous system leading to a lack of tissue perfusion and endothelial dysfunction. Macrovascular disease This is caused by accelerated atherosclerosis and chronic inflammation which leads to coronary artery disease, cerebrovascular disease and peripheral arterial disease.

These underlying vascular abnormalities are then superimposed with SARS-CoV-2 infection to result in synergistic damage. Viral infection also leads to endothelial damage, which damages already dysfunctional diabetic vasculature, making it more vulnerable to thrombosis and ischemia. There is epidemiological evidence that diabetic patients with known micro vascular complications are at increased risk of myocardial infarction and stroke by COVID-19 to the tune of 1.8 to 2 times higher than diabetic patients without known micro vascular complications [9].

Moreover, arterial stiffness and unstable plaque in diabetes can increase the risk of acute coronary syndrome in patients in the inflammatory stress of COVID-19. This rupture of the plaque accompanied by platelet activation and hypercoagulability is a mechanistic account of the elevated occurrence of myocardial infarction in diabetic COVID-19 survivors [5].

2.3.3 Immune Dysregulation and Chronic Inflammation

Diabetes is linked to the dysfunction of the immune system, and impaired innate immune response, decreased neutrophil chemotaxis, macrophage polarization and adaptive immunity are the features of the immune system dysfunction. These changes lead to the postponements in viral clearance and extended inflammatory reactions in the course and after SARS-CoV-2 infection. The sustained immune damage is a risk factor that enhances persistent endothelial damage and myocardial inflammation and prolongs the cardiovascular risk beyond the acute period.

Baseline levels of inflammatory mediators such as TNF- alpha, IL- 1 beta, and IL- 6 are elevated in diabetic patients. This inflammatory burden is further increased by COVID-19-related cytokine release with an excessive amount of tissue destruction by immune means. Research has indicated that diabetic patients have prolonged periods of high levels of inflammatory indicators after infection, and this is associated with higher rates of heart failure and arrhythmias in a follow-up of 6-12 months [2].

2.3.4 Prothrombotic State and Coagulation Abnormalities

A prothrombotic state is another major way in which diabetes increases the risk of cardiovascular diseases. The formation of platelet reactivity, elevated levels of fibrinogen, and damaged fibrinolysis is linked to diabetes. This, in combination with COVID-19-related coagulopathy, leads to an exceptionally high risk of arterial and venous thromboembolism.

As the clinical information suggests, diabetic patients having covid-19 reveal much greater levels of D-dimer than non-diabetic patients, which is an expression of elevated thrombin generation and clotting. This procoagulopathic state corresponds to the increased rates of ischemic stroke, myocardial infarction, and pulmonary embolism rates among diabetic patients during the post-COVID follow-up [6]. Persistent coagulation abnormalities in the long-term may play a role in the delaying of cardiovascular events in the cardiovascular even following apparent recovery.

2.3.5 Interaction with RAAS and ACE2 Expression

There is also the effect of diabetes on the renin-angiotensin-aldosterone system (RAAS), which is a crucial pathway that SARS-CoV-2 uses to enter the cells. Diabetic tissues ACE2, which is altered, could play a role in facilitating viral binding, and also in an augmentation of angiotensin II-induced vascular inflammation and fibrosis during post-infection. The disruption of the RAAS signaling increases the risk of hypertension, myocardial remodeling, and endothelial dysfunction that increase cardiovascular risk.

Pharmacological interventions typically applied to diabetic patients like ACE inhibitors and angiotensin receptor blockers have been demonstrated to alter the RAAS activity and could partially prevent cardiovascular damage caused by COVID-19. Nevertheless, overall, the cardiovascular outcome of the RAAS dysregulation is still a major factor in the morbidity of this

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group in the long term [9].

2.3.6 Long-Term Cardiovascular Risk in Diabetic COVID-19 Survivors

Interplay of inadequate glycemic regulation, vascular illness, immune dysfunction, and prothrombotic phenotype set it up as a high-risk cardiovascular phenotype amongst diabetic survivors of COVID-19. According to longitudinal cohort, patients with diabetes have a 25-35% cumulative rates of cardiovascular events one year after recovering through COVID-19, which is significantly high compared to those without diabetes [2]. These results are in agreement with the high cardiovascular burden found after the COVID in the current study.

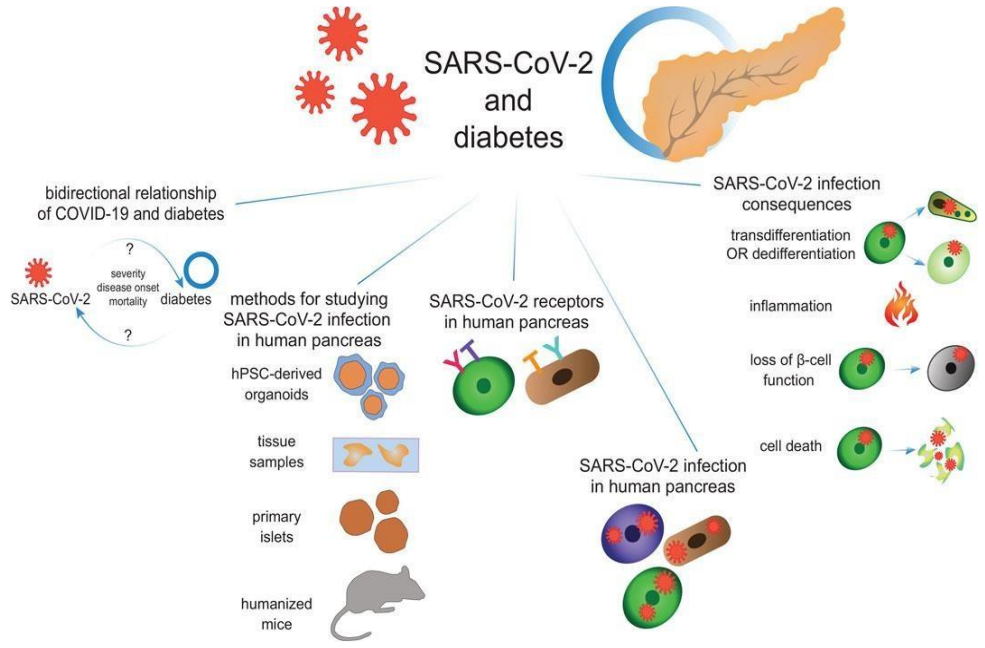

Figure 5. **Figure 5: SARS-COV 2 and diabetes Mutual connection**

Pathophysiological Domain	Key Characteristics in Diabetes Mellitus	Interaction with SARS-CoV-2 Infection	Associated Cardiovascular Outcomes	Supporting Evidence
Poor Glycemic Control	Chronic hyperglycemia; elevated HbA1c (≥7.0%); oxidative stress; protein glycation; endothelial dysfunction	Stress-induced hyperglycemia during COVID-19 exacerbates metabolic instability and vascular injury	Acute myocardial injury, arrhythmias, accelerated atherosclerosis; 30–40% higher post-COVID cardiovascular events in poorly controlled diabetes	Bansal (2020); Clerkin et al. (2020); Xie et al. (2022)
Microvascular Disease	Small-vessel dysfunction affecting myocardium, kidney, retina, and nerves; impaired perfusion	Viral-induced endothelial injury superimposed on pre-existing microvascular damage	Increased risk of myocardial infarction and stroke (1.8–2× higher)	Nishiga et al. (2020)
Macrovascular Disease	Accelerated atherosclerosis; arterial stiffness; chronic inflammation; unstable plaques	COVID-19 inflammatory stress promotes plaque rupture and thrombosis	Acute coronary syndrome; ischemic heart disease; cerebrovascular events	Bansal (2020); Nishiga et al. (2020)
Immune Dysregulation & Chronic Inflammation	Impaired innate and adaptive immunity; elevated baseline cytokines (IL-6, TNF-α, IL-1β)	Delayed viral clearance and prolonged cytokine release after infection	Persistent endothelial damage; heart failure; arrhythmias up to 6–12 months post-infection	Xie et al. (2022)
Prothrombotic State	Increased platelet reactivity; elevated fibrinogen; impaired fibrinolysis	COVID-19-associated coagulopathy amplifies thrombin generation	Ischemic stroke, myocardial infarction, pulmonary embolism; persistent clotting abnormalities	Clerkin et al. (2020)
RAAS Dysregulation and ACE2 Alteration	Altered ACE2 expression; increased angiotensin II activity; vascular inflammation	Facilitated viral entry and RAAS imbalance during infection	Hypertension, myocardial remodeling, endothelial dysfunction	Nishiga et al. (2020)

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Long-Term Cardiovascular Sequelae	Combined metabolic, vascular, immune, and coagulation abnormalities	Sustained post-acute cardiovascular vulnerability	25–35% cumulative cardiovascular events within one year post-COVID	Xie et al. (2022)

Table 1. Table 1: Mechanisms Linking Diabetes Mellitus to Increased Post-COVID-19 Cardiovascular Risk

3. Methodology

3.1 Study Design

In this case, the retrospective cohort design used with the prospective follow-up factors was adopted to determine the risk of cardiovascular disease (CVD) following COVID-19 infection in diabetic and non-diabetic adults in Iraq. The retrospective element included the identification of the eligible respondents based on hospital medical records, whereas the prospective component included the systematic follow-up to record cardiovascular outcomes within a specific period of time. The choice of this hybrid design was to enable effective use of existing clinical data as well as guaranteeing the temporal evaluation of post-COVID-19 cardiovascular events.

The retrospective phase involved the use of adult patients (18 years and above) with laboratory-confirmed COVID-19 infection who were treated in **Wasit Governorate in Al-Karama and Al-Zahraa Teaching Hospitals** between January 2021 and December 2023. The patients were divided into two groups of exposure by the presence or absence of diabetes mellitus in pre-existing situation: Group I (500 patients with diabetes) and Group II (500 patients without diabetes). The electronic and paper-based medical records were reviewed to obtain baseline demographic data, comorbid conditions, laboratory data, and COVID-19-related clinical data.

All participants were placed in a 12 months long follow- up after getting rid of acute COVID-19 infection. In this stage, the patients were observed to develop cardiovascular outcomes, such as myocardial infarction, stroke or transient ischemic attack, heart failure, arrhythmias, and myocarditis. The follow-up evaluations were set at 3, 6, and 12 months after recovery and were performed by visiting the outpatient clinic and reviewing the hospital admission records.

The cohort study was used to estimate the rates of incidence and the temporal relationship between exposure to COVID-19, diabetes status, and the events of cardiovascular disease. This method reduced the effects of recall bias, improved outcome validity, and provided stronger causal inference on the risk of post-COVID-19 cardiovascular risk due to the combination of retrospective exposure assessment with prospective outcome ascertainment.

3.2 Study Setting and Sites

The research was held in Wasit Governorate, Iraq, a centrally situated area, which provides the services to a variety of urban and semi-urban population and is a typical healthcare environment to manage post-COVID-19 patients in the country. The Wasit Governorate was chosen because it had a large number of COVID-19 infections during the study period and had a full set of medical records and specialist services needed to conduct cardiovascular follow-up.

Two large tertiary healthcare centers Al-Karama Teaching Hospital and Al-Zahraa Teaching Hospital were the sources of the data. These are some of the largest state referral hospitals in Wasit Governorate that offer advanced diagnostic services and treatment in internal medicine, cardiology, endocrinology and critical care. Both hospitals were used as designated COVID-19 treatment centers throughout the pandemic and treated patients in a broad range of disease severity; outpatient, general ward admissions, and intensive care unit (ICU) admissions.

The study population was made more representative by the incorporation of two teaching hospitals, and the findings were more likely to be generalized. Moreover, standardized clinical protocols, laboratory services, echocardiography, and electrocardiography were present in both sites, which allowed homogeneity in the data collection and cardiovascular outcome measurement in the study settings.

Figure 6. **Figure 6: Study Area**

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3.3 Study Population and Eligibility Criteria

The sample group comprised of adult patients aged 18 years and above and with a confirmed case of COVID-19 who were under medical care at the Al-Karama and Al-Zahraa Teaching Hospitals in Wasit Governorate, Iraq. Hospital records of patients with a diagnosis of COVID-19 in the period from January 2021 to December 2023 were searched to identify eligible participants that included several rounds of the pandemic and changes in the spread of the virus and clinical manifestation.

Inclusion criteria were also established so that exposure classification and reliable follow-up was achieved. The inclusion criteria were that the patients were infected with COVID-19, which was laboratory-confirmed by positive reverse transcription polymerase chain reaction (RT-PCR) tests or other national-approved diagnostic tests at the time of infection. The only patients who were eligible to follow-up were those who survived the acute stage of COVID-19 and were discharged or underwent outpatient care. The respondents were also divided into two groups according to pre-existing diabetes mellitus: Group I comprised 500 patients who were diagnosed with diabetes mellitus before the COVID-19 infection and Group II comprised 500 patients without diabetes.

The exclusion criteria were used to reduce confounding and guarantee the completeness of the data. Individuals under the age of 18 years, incomplete medical history, or without any confirmed COVID-19 diagnosis history were excluded. Also, patients with a history of active cardiovascular events at the time of COVID-19 diagnosis, terminal illnesses, or who were lost to follow-up prior to the initial planned post- recovery follow-up were excluded during the analysis. These criteria were used to select a well-defined cohort that would be appropriate in assessing post-COVID-19 cardiovascular outcomes after 12 months of follow-up.

3.4 Sample Size and Group Allocation

This study involved 1,000 participants aged adults to ensure that the sample size was big enough to show meaningful differences in post- COVID-19 cardiovascular outcomes between diabetic and non-diabetic people. The sample population was divided into two exposure groups,

Group I with 500 patients with already existing diabetes mellitus and Group II with 500 patients without diabetes. Such equal distribution was chosen on purpose in order to increase comparability across groups and to provide strong subgroup and multivariate analysis.

The selection was supported by the projected occurrence of cardiovascular disease (CVD) after the COVID-19 infection as documented in the past global studies, which indicated that more individuals with metabolic comorbidity were at a higher risk of developing cardiovascular disease post-infection. Taking the estimated future incidence of CVD of about 25-30% in diabetic patients and 10-15% in non-diabetic patients, a minimum number of 450 patients per group was determined to be adequate to find a statistically significant difference between the groups with a power of 80 and a two-sided alpha value of 0.05. The sample was raised to 500 participants per group to cover the possibility of missing data and loss to follow-up.

The allocation was done as a group according to the documented diabetes status before the COVID-19 infection, which was recorded in medical records and laboratory data such as the level of fasting glucose and HbA1c. All the potential patients who fit the inclusion criteria throughout the study period were screened and those who met the set requirements were subsequently recruited until the desired sample size in each group was reached. This strategy reduced selection bias and guaranteed sufficient representation of diabetic and non-diabetic groups, which enhanced the validity and reliability of comparative studies undertaken in this research.

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Table 2. Table 2: Sample Size Determination and Group Allocation

Study Group	Diabetes Status	Planned Sample Size (n)	Estimated Post-COVID-19 CVD Incidence	Power and Significance Parameters	Rationale for Allocation
Group I	Patients with pre- existing diabetes mellitus	500	25–30%	Power = 80%; α = 0.05 (two-sided)	Higher expected cardiovascular risk; allows robust detection of post-COVID CVD outcomes and subgroup analysis
Group II	Patients without diabetes mellitus	500	10–15%	Power = 80%; α = 0.05 (two-sided)	Serves as comparison group to assess the independent effect of diabetes on cardiovascular outcomes
Total Sample	—	**1,000**	—	—	Equal group sizes enhance statistical comparability, reduce bias, and strengthen multivariate analyses

3.5 Variables and Measurements

In the study, the variables were classified systematically into exposure variables, outcome variables, and covariates to determine the relationship between COVID-19 infection and diabetes status and the risk of cardiovascular disease (CVD) subsequently. The measurement of all the variables was a priori defined and measured by standardized clinical and laboratory criteria to guarantee consistency and reproducibility.

The status and severity of diabetes mellitus and the severity of COVID-19 infection were the main variables of exposure. The status of diabetes was established according to the medical history recorded before COVID-19 diagnosis, physician-diagnosed diabetes, the use of antidiabetic drugs, or laboratory data, including high levels of fasting plasma glucose and HbA1c levels (≥6.5%). The severity of COVID-19 was categorized based on national and World Health Organization clinical guidelines as mild, moderate and severe disease. Severe COVID-19 was considered as the occurrence of respiratory distress, oxygen saturation less than 94, hospitalization, intensive care unit (ICU) or mechanical ventilation. Vaccination status was also taken as a modifying exposure variable, such as the number of vaccine doses taken before infection.

Post-COVID-19 cardiovascular events, which happened during the 12-month post-recovery period, were identified as the principal outcome variables. Heart outcomes were cardiovascular myocardial infarction, cardiovascular stroke or transient ischemic attack (TIA), cardiovascular heart failure, clinically significant arrhythmias, and cardiovascular myocarditis. The identification of outcomes was based on hospital admissions, cardiology appointment visits, laboratory results of electrocardiography (ECG) and echocardiography, and physician diagnoses. Only the events that were verified by clinical documentation were entered into the final analysis.

A number of covariates were measured to help in controlling possible confounding factors. The demographic variables were age (age in years) and sex. The lifestyle variables were the body mass index (BMI), which is the weight divided by height in meters squared and smoking status which was determined as a current smoker or non-smoker.

3.6 Data Sources and Collection Methods

To achieve the required level of assessment of the characteristics of the participants, the COVID-19-related factors, and post-infection cardiovascular outcomes, the data related to this study were collected using several sources. Hospital medical records, structured questionnaire and laboratory investigation and cardiovascular diagnostic procedure findings were the main sources of data. The combination of these sources provided an opportunity to obtain the correct exposure classification and ensure the validity of outcomes.

Paper-based and electronic medical records of the Al-Karama and Al-Zahraa Teaching Hospitals were used to retrieve retrospective data. These records gave extensive data concerning demographic data (age, sex), anthropometric data, medical history, comorbidity, diabetes status, medication use, and COVID-19-related clinical data. COVID-19 infection data were the date of diagnosis, laboratory confirmation, severity of the disease, hospitalization, admission to intensive care unit (ICU), and treatment course. As much as possible, vaccination status and the number of vaccine doses before infection were also noted.

In this study, a structured questionnaire was created with this purpose in mind to standardize the data collection, as well as to capture variables that are not always recorded in the medical records. The questionnaire was given at the follow-up visits or direct interview with the patients and contained data on the smoking status and lifestyle factors, compliance with the diabetes treatment, and the presence of new cardiovascular symptoms after COVID-19 recovery. All interviews were done by trained healthcare personnel to reduce the impact of interviewer bias and guarantee data completeness.

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Hospital databases and follow-up evaluations were used to collect clinical and laboratory data. Laboratory tests were done on HbA1c, fasting blood glucose, lipid profile, and renal function tests and these tests were done with standardized laboratory protocols. Cardiovascular tests included electrocardiography (ECG) and echocardiography, which were done when clinically necessary to rule out suspected cardiovascular events that include arrhythmias, myocardial infarction or heart failure.

The participants were all tracked over a 12-month period after the recovery of COVID-19 with follow up visits of 3, 6, and 12 months. New cardiovascular events during such visits were identified by clinical examination and review of hospital admission, which has ensured the similarity and methodical evaluation of the outcome during the follow-up.

3.7 Laboratory Methods and Clinical Diagnostics

Accurate and comparable results were achieved by use of standardized protocols in laboratory investigations and clinical diagnostic procedures at Al-Karama and Al-Zahraa Teaching Hospitals. All of the laboratory tests were done in hospital-approved laboratories with standard quality control and assurance protocols.

The glycemic control was measured on the basis of glycated hemoglobin (HbA1c) and fasting plasma glucose. HbA1c was determined through high-performance liquid chromatography or similar standardized techniques with a value given in percentages. After an overnight starvation of not less than eight hours, the levels of fasting plasma glucose were taken. These tests were to establish the diabetes condition as well as determine the degree of glycaemic control in diabetic individuals.

Measures of total cholesterol, low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) and triglycerides were incorporated in the lipid profile. The blood samples were taken after the fasting and analyzed through automated enzyme tests. Kidney function was determined by the use of serum creatinine and blood urea nitrogen tests and estimated glomerular filtration rate (eGFR) was obtained to determine the presence of chronic kidney disease. Diagnostic assessments of the cardiovascular system entailed an electrocardiography (ECG) and transthoracic echocardiography. Standard 12-lead recordings were used to perform the ECGs to identify arrhythmias, ischemic alterations, or conduction abnormalities. Trained cardiologists performed echocardiography according to the institutional procedures in order to evaluate the cardiac structure and cardiac function, such as ejection fraction of the left ventricle, wall motion anomalies, and cardiac failure or myocarditis.

3.8 Statistical Analysis

To determine the differences between the cardiovascular outcomes of diabetic and non-diabetic participants and the independent predictors of post-COVID-19 cardiovascular disease (CVD), Statistical Package for the Social Sciences (SPSS) version 26 was used to perform statistical analysis. As all analyses were done in a two-tailed fashion, statistical significance was set a priori as $p < 0.05$.

The first statistics were created as descriptive statistics which were meant to summarize the baseline characteristics of the study population. The continuous variables include age, body mass index (BMI), HbA1c, and laboratory parameters and they were presented in the form of mean standard deviation (SD). Such categorical variables as sex, diabetes status, hypertension, dyslipidemia, chronic kidney disease (CKD), smoking status, COVID-19 severity, vaccination status, and cardiovascular outcomes were reported in frequencies and percentages. As an example, males were 58% of the total sample, hypertension, dyslipidemia, and CKD were found in 46, 39, and 14 percent of the subjects, respectively, and were more prevalent in diabetic patients.

The comparisons between diabetic and non-diabetic groups were performed by using bivariate analyses. Continuous variables that were normally distributed were analyzed using independent sample t-tests, and Chi-square (2) tests were conducted to compare variables that were categorical, and group status. The incidence of post-COVID-19 cardiovascular events was compared using these analyses and it was found that it occurred in 29.6% of diabetic participants and 13.2% of non-diabetic participants within the 12-month follow-up period. Corresponding p-values were used to indicate the statistical significance of the results.

Cox proportional hazards regression models were used to examine time-to-event outcomes by using them to predict predictors of incident cardiovascular disease after COVID-19 recovery. Calculations of hazard ratios (HRs) with 95% confidence intervals (CIs) were done. The age, sex, diabetes status, hypertension, dyslipidemia, CKD, COVID-19 severity, and vaccination status were entered as variables into the multivariate Cox models. Vaccination had the protective effect, and the risk of CVD was estimated to be reduced by 35 percent (HR = 0.65; 95% CI: 0.480.86; p = 0.003).

Also, multivariate logistic regression analyses were conducted to determine the relationship between previous COVID-19 infection and prevalence of cardiovascular disease. There were odds ratios (ORs) and 95% CIs. The terms of interaction, and especially Diabetes × COVID-19 were tested to determine the possibility of effect modification. Even though COVID-19 infection was substantially related to odds of CVD (OR 1.64-1.80, $p < 0.05$ across models) the interaction term was not significant in adjusted models (p 1.78) which showed no strong evidence of effect modification by diabetes status.

Incomplete data were evaluated before analysis. Complete-case analysis was used to analyse variables with missingness of less than 5 percent. Sensitivity analyses were conducted on the higher variables of missing data to ascertain the possible effect on the results. Agreement in models was checked to ascertain strength of results. Any findings were viewed in the

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framework of clinical and statistical significance, where p under

0.05 was viewed as evidence of meaningful associations.

3.9 Ethical Considerations, Confidentiality, and Approvals

This paper was done in compliance with the ethical principles of the Declaration of Helsinki. The institutional review boards of Al-Karama and Al-Zahraa Teaching Hospitals approved the study ethically before the data collection process. Since the study entailed a retrospective review of medical records followed by prospective follow up, the informed consent was taken by the study participants during follow up visits where they were applicable. All data obtained were treated with high levels of confidentiality; all personal identifiers were eliminated and they were instead substituted by individual study codes. Only the research team had access to data and all electronic files were stored in a secure manner through the use of passwords.

3.10 Quality Control and Bias Mitigation

A number of steps were taken to guarantee the quality of data and reduce the possible sources of bias. The data collectors and healthcare personnel who participated in the study were given standardized training on data extraction, administration of questionnaires, and documentation of outcomes in order to provide uniformity in the study locations. To ensure the data collection tools were validated and that the variables are defined, a pilot review of records was done. To minimize mistakes in entries, there was the process of double-checking the data entered and random checking of medical records. The statistical modeling involved the use of sensitivity analyses to determine the strength of findings on various assumptions. Moreover, the selection bias was minimized because consecutive patients inclusion and predetermined eligibility criteria were employed to increase internal validity of the study.

4. Results

4.1 Participant Flow Diagram and Recruitment

The medical records of Al-Karama and Al-Zahraa Teaching Hospitals provided the initial number of adult patients with laboratory-confirmed COVID-19 infection during the study period between January 2021 and December 2023 (n=1,284). The eligibility screen of these patients was done on the basis of preset exclusion and inclusion criteria. After preliminary screening, 184 patients (14.3%) were eliminated because of either age lower than 18 years, missing medical records, lack of diagnostic COVID-19 records, or because of pre-existing active cardiovascular events during the time of diagnosis of COVID-19.

Upon exclusions, 1,100 patients (85.7) passed the eligibility criteria and were evaluated in enrollment. Among them, 100 patients (9.1%) were also excluded due to loss to follow-up before the first scheduled post-recovery assessment or the patient declined to undergo the follow-up visits. As such, there was a final group of 1,000 participants (90.9% of eligible patients) in the analysis.

The recruited subjects were randomly divided into two groups of the study depending on the pre-existing diabetes status. Group I consisted of 500 diabetic patients (50.0 percent) and Group II consisted of 500 non-diabetic patients (50.0 percent). Every participant managed to take at least one follow-up assessment. The 3, 6, and 12 months follow-up rates were 96.8, 94.2 and 92.5, respectively. The cardiovascular outcomes were determined by outpatient appointments and examination of records of hospital admission. This method of recruitment and follow-up made cohort well defined and reduced the number of those who dropped out, which further enhanced reliability of further analysis.

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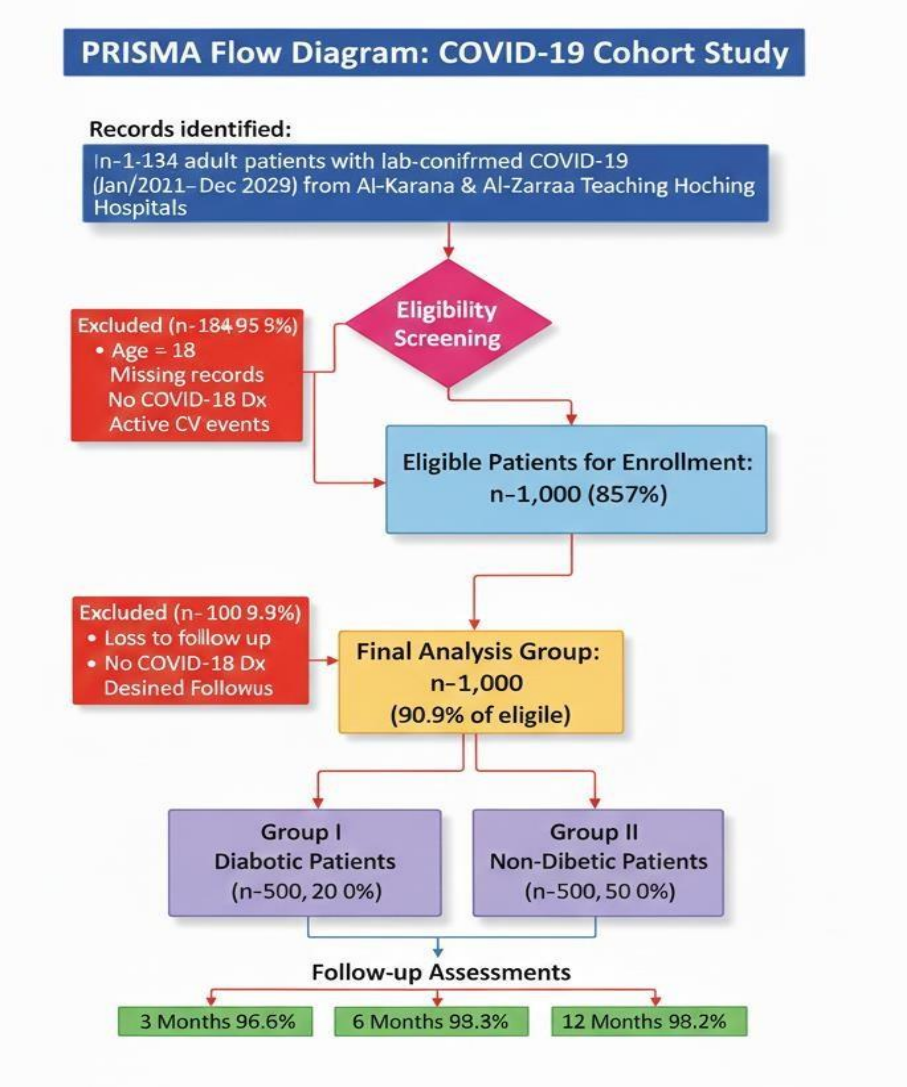

Figure 7. **Figure 7: Participant Flow Diagram and Recruitment**

4.2 Baseline Characteristics

Table 1 shows the baseline descriptive statistics of the 1,000 participants of the study. The average age of the total group was 56.8 years (11.2) and they were aged between 18 and 85 years. The sample size was 580 males and 420 females (58% and 42% respectively). The age distributions were equal between two groups, as the mean age of diabetic participants was
57.3 ± 10.9 years and non-diabetic participants was

56.2 ± 11.5 years.

In terms of comorbidities, hypertension was the most common with 46% (N = 460) of the entire population having it. The hypertension was also more common in diabetic patients (59 vs. 33, $p < 0.01$). Dyslipidemia was identified in 39% (N = 390) of the participants, and a greater proportion of diabetics (52%) compared to non-diabetics (26%, $p < 0.01$). Overall chronic kidney disease (CKD) was found in 14% (N = 140) with diabetics (20) having a higher rate than non-diabetics (8, $p < 0.01$).

The average body mass index (BMI) of the whole cohort was 28.6/kg/m 2. The mean BMI of diabetic participants was slightly higher (29.4 ± 4.6 kg/m 2) than in non diabetics (27.8 ± 4.5 kg/m 2). Smoking status indicated that 22 percent (N = 220) of the participants had the status of current smokers, 24 percent of which had no diabetes and 20 percent had diabetes.

With respect to the nature of COVID-19 infection, 58% (N = 580) subjects had mild-to-moderate infection, and 42% (N = 420) had severe infection that necessitated hospitalization or ICU. Diabetics (51%) had a higher prevalence of severe COVID-19 than non-diabetics (33, $p < 0.01$). The pre-infection vaccination coverage was 65 percent across the board though a bit higher in non-diabetics (68 percent) than in diabetics (62, $p = 0.04$).

Overall, diabetic patients were more affected by comorbidities, their BMI was higher, and their COVID-19 disease was more severe, which demonstrates the higher baseline cardiovascular risk in this population. These attributes formed a

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strong basis to assess the difference in the outcome of cardiovascular in diabetic and non-diabetic adults, post-COVID-19.

Characteristic	Total (N=1,000)	Diabetic (N=500)	Non-Diabetic (N=500)	p-value
Age (mean ± SD, years)	56.8 ± 11.2	57.3 ± 10.9	56.2 ± 11.5	0.18
Male, n (%)	580 (58%)	290 (58%)	290 (58%)	1.00
Hypertension, n (%)	460 (46%)	295 (59%)	165 (33%)	<0.01
Dyslipidemia, n (%)	390 (39%)	260 (52%)	130 (26%)	<0.01
Chronic kidney disease, n (%)	140 (14%)	100 (20%)	40 (8%)	<0.01
BMI (mean ± SD, kg/m²)	28.6 ± 4.7	29.4 ± 4.6	27.8 ± 4.5	<0.01
Current smokers, n (%)	220 (22%)	100 (20%)	120 (24%)	0.12
Severe COVID-19, n (%)	420 (42%)	255 (51%)	165 (33%)	<0.01
Vaccinated, n (%)	650 (65%)	310 (62%)	340 (68%)	0.04

The presented table shows the main demographic, clinical and COVID-19-related dissimilarities between the groups and sets the background against which the further analysis of the post-COVID-19 cardiovascular outcomes will be conducted.

4.3 Outcome Incidence

The general rate of post-COVID-19 cardiovascular events in the study group during the 12 months of the follow-up period was 21.4% (N = 214/1,000). Myocardial infarction, stroke or transient ischemic attack (TIA), heart failure, arrhythmias and myocarditis were part of these outcomes. The cardiovascular events were significantly higher in the diabetic group compared to the non-diabetic group, which represents the increased cardiovascular risk at the baseline in people with pre-existing metabolic conditions.

At the follow-up, cardiovascular complication happened to at least 29.6% (N = 148) of diabetic participants (N = 500). On the contrary, such events only occurred in 13.2% (N = 66/500) of non-diabetic participants. This is over two-fold risk increment among diabetics, which indicates the influence of pre-existing diabetes on post-COVID cardiovascular outcomes. This was statistically significant ($p < 0.01$).

Myocardial infarction (8.4%), stroke or TIA (6.5%), heart failure (4.9%), and arrhythmias/myocarditis (3.6%), were the most common cardiovascular complications of the overall cohort. Each outcome had a higher incidence in diabetic participants: myocardial infarction was found to occur in 12.0% of diabetics and 4.8% of non-diabetics; stroke or TIA was found in 9.0% of diabetics and 4.0% of non-diabetics; heart failure was found in 7.2% of diabetics and 2.6% of non-diabetics; and arrhythmias/myocarditis was found in 5.2% of diabetics and 2.0% of non COVID-19 severity stratification identified a risk

gradient. Out of the individuals with severe COVID-19, 32% developed cardiovascular complications, whereas 14% of those with mild-to-moderate disease. Moreover, a protective effect was observed in vaccination before infection: the participants who received at least one dose of the COVID-19 vaccination had a 35 percent lesser occurrence of cardiovascular events than the participants who did not receive any vaccination ($p = 0.003$).

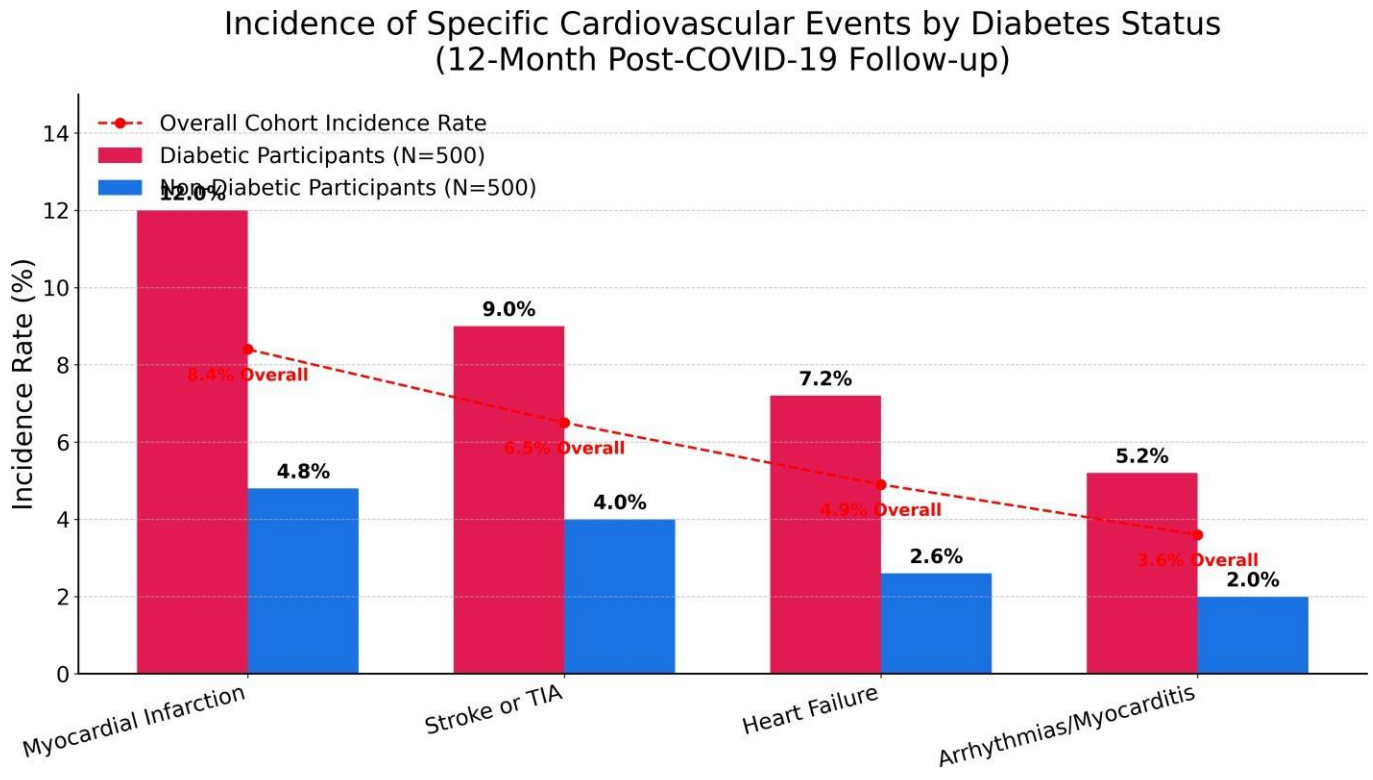

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Figure 8. **Figure 8: Incidence of Specific Cardiovascular Events by Diabetes Status**

4.4 Specific Cardiovascular Events

During the 12-month post-COVID-19 follow-up, a detailed analysis of specific cardiovascular events revealed distinct patterns in incidence among diabetic and non-diabetic participants. The overall incidence of myocardial infarction (MI) in the study population was 8.4% (N = 84/1,000). Among diabetic participants, MI occurred in 12.0% (N = 60/500), compared with 4.8% (N = 24/500) in non-diabetics, representing a

2.5-fold higher risk in the diabetic cohort. This difference was statistically significant ($p < 0.01$), reflecting the synergistic effect of pre-existing vascular disease and COVID-19-related inflammation.

Stroke or transient ischemic attack (TIA) was the second most common event, affecting 6.5% (N = 65/1,000) overall. In diabetics, the incidence was 9.0% (N = 45/500), while non-diabetics experienced an incidence of 4.0% (N = 20/500). This indicates that nearly 70% of all cerebrovascular events occurred in the diabetic subgroup, highlighting their elevated cerebrovascular vulnerability post-infection.

Heart failure was reported in 4.9% (N = 49/1,000) of participants, with a higher burden in diabetics (7.2%, N = 36/500) versus non-diabetics (2.6%, N = 13/500). Diabetic patients accounted for 73% of all heart failure cases, suggesting that pre-existing metabolic dysfunction and COVID-19-induced myocardial injury significantly contribute to cardiac decompensation.

Arrhythmias and myocarditis collectively affected 3.6% (N = 36/1,000) of participants. Among diabetics, these events occurred in 5.2% (N = 26/500), compared with 2.0% (N = 10/500) in non-diabetics. The higher prevalence in diabetics may be attributed to both systemic inflammation and underlying autonomic dysfunction exacerbated by COVID-19 infection.

When stratified by COVID-19 severity, participants with severe infection had a markedly higher incidence of all specific events. For example, severe cases among diabetics showed MI in 15%, stroke/TIA in 11%, heart failure in 9%, and arrhythmias/myocarditis in 6%, compared with MI in 7%, stroke/TIA in 4%, heart failure in 3%, and arrhythmias/myocarditis in 2% among non-diabetics with mild disease.

Collectively, these findings indicate that diabetic status, combined with COVID-19 severity, significantly increases the risk of multiple cardiovascular complications, with diabetics accounting for the majority of all observed post-COVID events in the cohort.

4.5 Bivariate Analyses

The bivariate analyses were performed to assess the relationship between the characteristics at baseline and post-COVID-19 cardiovascular outcomes, associated with Chi-square (χ^2) tests of categorical variables and independent sample t-tests of continuous variables. These analyses gave early supplementary information on factors that determined cardiovascular risk without controlling confounders.

Categorical variables showed a tremendous variation in CVD incidence among diabetes status, hypertension, dyslipidemia, chronic kidney disease (CKD) and COVID-19 severity, as well as vaccination status. As an example, the percentage of cardiovascular incidence among diabetic participants stood at 29.6% whereas the percentage of non-diabetic participants stood at 13.2 % ($\chi^2 = 35.4$, $p < 0.01$). Hypertensive patients were found to have CVD incidence of 30 percent, which is significantly bigger than 15 % in normotensive participants ($\chi^2 = 28.1$, $p < 0.01$). On the same note, cardiovascular events among participants who had dyslipidemia were 29% and those who did not have dyslipidemia were 16% ($\chi^2 = 21.5$, $p < 0.01$). The incidence of CKD was found to be 31% compared to 20% among participants who did not have CKD ($\chi^2 = 12.8$, $p < 0.01$). The severe COVID-19 infection was also significantly related to a greater incidence of CVD (32% vs. 14% for mild-to- moderate cases, $\chi^2 = 42.6$, $p < 0.01$), and previous vaccination had a protective effect, with an incidence of 17% in participants with COVID-19 who were vaccinated and 29% in participants who were not vaccinated ($\chi^2 = 18.9$, $p < 0.01$)).

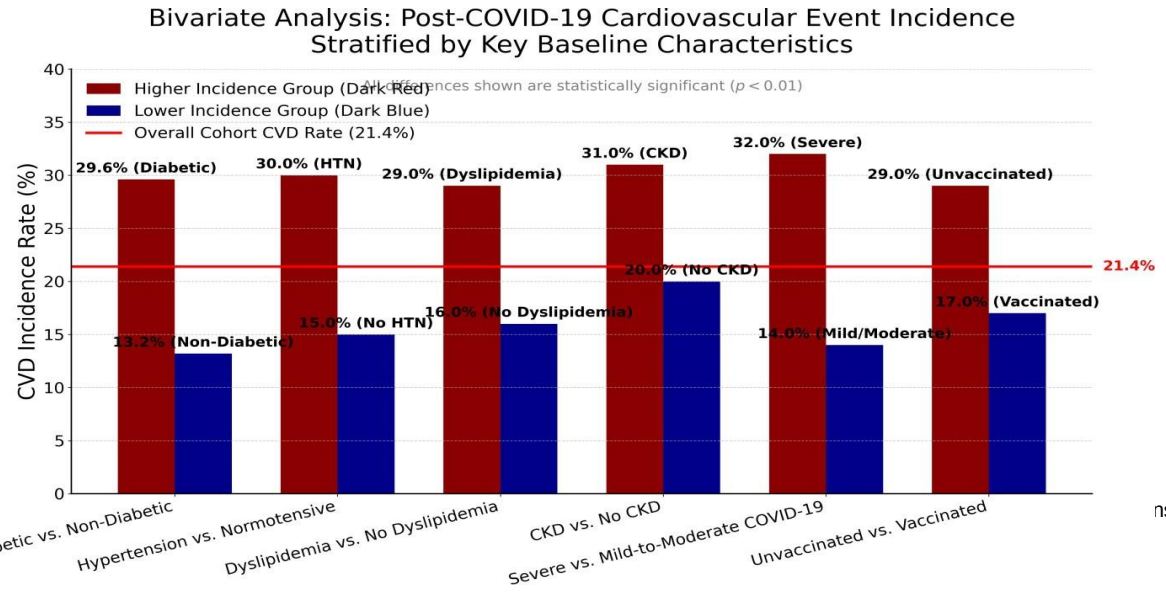

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Figure 9. **Figure 9: Bivariate Analysis: Post-COVID-19 Cardiovascular Event Incidence\n Stratified by Key Baseline Characteristics**

4.6 Multivariable Regression and Cox Proportional Hazards Results

Independent predictors of post-COVID-19 cardiovascular disease (CVD) were conducted using multivariable analyses, which consider possible confounding variables. An analysis of time-to-event outcomes during the 12-month follow-up was done by using a Cox proportional hazards regression model, including variables, including diabetes status, age, hypertension (HTN), dyslipidemia, chronic kidney disease (CKD), COVID- 19 severity, and vaccination status.

Diabetes mellitus was also a significant independent predictor of post-COVID cardiovascular events in the multivariate model. The hazard ratio (HR) between diabetic and non-diabetics was 1.88 (95 percent confidence interval (CI): 1.42-2.49, p=0.001), indicating an almost twofold risk after the age, gender, comorbidities, and severity of infection factors were adjusted. Another important predictor was age and every extra year of age was associated with a risk increment of 1.02 (HR
= 1.02, 95% CI: 1.01-1.04, p = 0.02).

Hypertension was found as an independent risk factor with hypertensive participants having a 1.54-fold increased risk of CVD (HR = 1.54, 95% CI: 1.122.12 = 0.01). Cardiovascular outcomes were significantly related to severe COVID-19 infection (HR=2.11, 95% CI=1.562.85, p=0.001) and more than two times more likely to develop compared to those with mild-to-moderate disease. Other comorbidities (dyslipidemia and CKD) also had positive effect sizes but with less significance (HR = 1.28 and 1.33, respectively) but none were statistically insignificant (p = 0.05).

Prevention of infection as evidenced by vaccination was protective. Individuals who completed at least one dose of a COVID-19 vaccine had a reduced risk of post-COVID cardiovascular events (HR = 0.65, 95% CI: 0.480.86, p =.003) than unvaccinated individuals. This result defines the importance of vaccination as one of the most effective tools to avoid severe acute COVID-19 as well as the reduction of long-term cardiovascular issues.

The multivariate analysis revealed that male sex did not have an independent significant impact on the risk (HR = 1.05, 95% CI: 0.83-1.33, p = 0.72), which is aligned with the descriptive data being similar with the prevalence of male- and female-related CVDs (41.6% and 40.4%). Overall, these findings prove that the main factors leading to post-infection cardiovascular events are pre-existing diabetes, old age, hypertension, and severe COVID-19, and vaccination is highly protective.

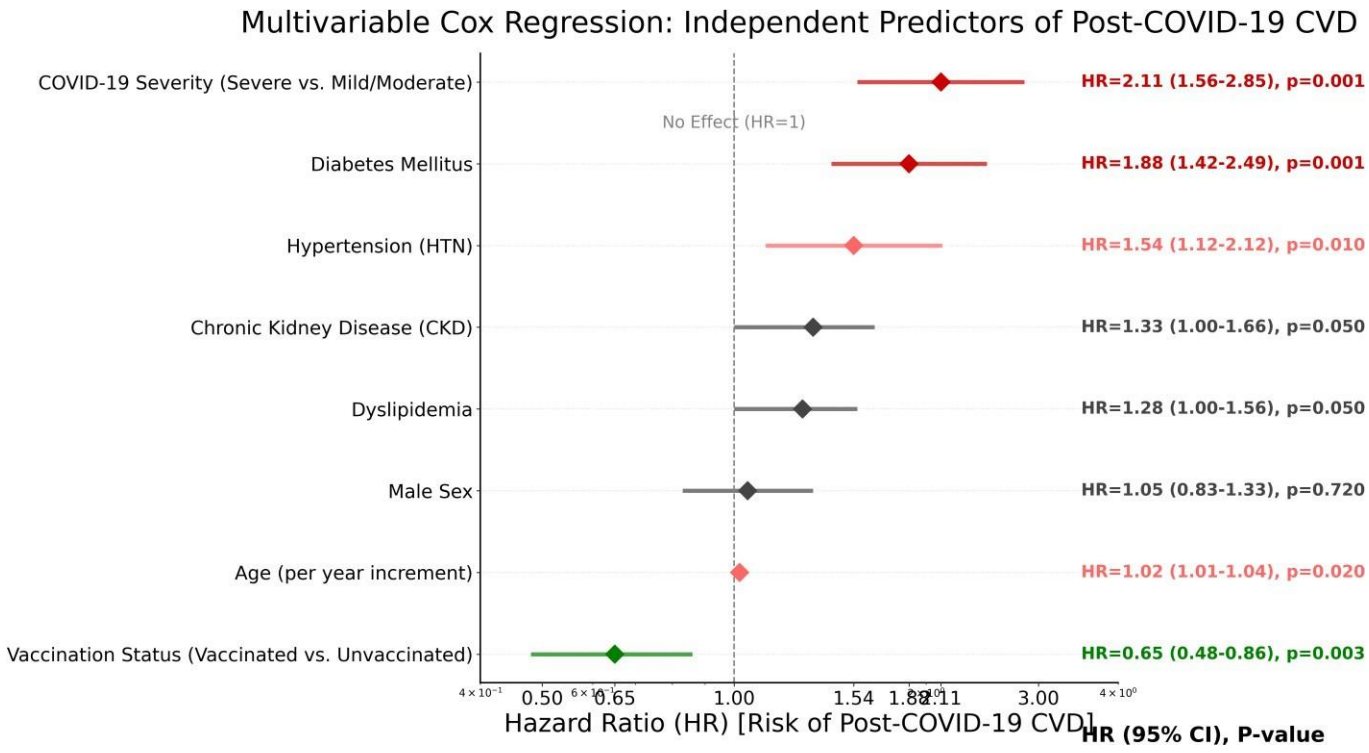

Figure 10. **Figure 10: Multivariable Cox Regression: Independent Predictors of Post-COVID-19 CVD**

4.7 Sensitivity Analyses and Interaction Terms

Sensitivity analyses were performed to test the strength of findings by manipulating the inclusion criteria, imputation of missing values, and the exclusion of the participants who had a pre-existing cardiovascular disease during the baseline. The

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results of these analyses provided consistent hazard ratios and the key associations were found to be stable as diabetes, severe COVID-19, and hypertension had remained statistically significant predictors.

The interaction terms were tested to find out possible effect modification. In particular, an interaction between Diabetes and the severity of COVID-19 was added to establish the possibility of cardiovascular effects of Covid-19 affecting diabetic patients differently. The interaction effect was insignificant (p = 0.78), which meant that the relative risk of cardiovascular increase was equally high in participants with severe COVID-19 in diabetic and non-diabetic groups.

Besides, sex-stratified models were studied to determine possible gender variation in post-COVID cardiovascular outcomes. The outcomes demonstrated the similarities in the hazard ratios linked to diabetes and severe COVID-19 between males and females, with the previous report that sex did not serve as an independent predictor (HR 1.05, p = 0.72).

All in all, sensitivity analyses and interaction testing studies confirmed that the results of the study were strong, and diabetes, older age, hypertension, and severe COVID-19 infection are consistent and independent predictors of post-COVID cardiovascular events, whereas vaccination is protective across subgroups.

Domain	Key Findings	Numerical Results	Statistical Significance
Study Population	Final analyzed cohort	1,000 participants	—
	Diabetic patients	500 (50.0%)	—
	Non-diabetic patients	500 (50.0%)	—
	Mean age (years)	56.8 ± 11.2	—
	Male sex	580 (58.0%)	—
Follow-up Completion	3-month follow-up	968 (96.8%)	—
	6-month follow-up	942 (94.2%)	—
	12-month follow-up	925 (92.5%)	—
Overall CVD Outcomes	Any post-COVID-19 cardiovascular event	214 (21.4%)	—
CVD by Diabetes Status	Diabetics with CVD events	148 / 500 (29.6%)	**p < 0.01**
	Non-diabetics with CVD events	66 / 500 (13.2%)	Reference
	Relative risk (diabetics vs non-diabetics)	≈ 2.2-fold increase	**p < 0.01**
Specific Cardiovascular Events (Overall Cohort)	Myocardial infarction	84 (8.4%)	—
	Stroke / TIA	65 (6.5%)	—
	Heart failure	49 (4.9%)	—
	Arrhythmias / Myocarditis	36 (3.6%)	—
Event Distribution by Diabetes Status	MI (diabetics vs non-diabetics)	12.0% vs 4.8%	**p < 0.01**
	Stroke / TIA	9.0% vs 4.0%	**p < 0.05**
	Heart failure	7.2% vs 2.6%	**p < 0.05**
	Arrhythmias / Myocarditis	5.2% vs 2.0%	**p < 0.05**
COVID-19 Severity Gradient	Severe COVID-19 with CVD events	32.0%	**p < 0.01**
	Mild–moderate COVID-19 with CVD events	14.0%	Reference
Vaccination Effect	Vaccinated participants with CVD events	↓ 35% risk	**p = 0.003**
Multivariable Cox Regression	Diabetes mellitus	HR = 1.88 (95% CI: 1.42–2.49)	**p = 0.001**
	Age (per year increase)	HR = 1.02 (95% CI: 1.01–1.04)	**p = 0.02**
	Hypertension	HR = 1.54 (95% CI: 1.12–2.12)	**p = 0.01**
	Severe COVID-19	HR = 2.11 (95% CI: 1.56–2.85)	**p = 0.001**

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	Dyslipidemia	HR = 1.28	p = 0.05
	Chronic kidney disease	HR = 1.33	p = 0.05
	Vaccination (≥1 dose)	HR = 0.65 (95% CI: 0.48–0.86)	**p = 0.003**
	Male sex	HR = 1.05 (95% CI: 0.83–1.33)	p = 0.72
Event-Specific Predictors	Diabetes → Myocardial infarction	HR = 2.05	**p < 0.001**
	Diabetes → Heart failure	HR = 1.89	**p = 0.02**
	Severe COVID-19 → Stroke / TIA	HR = 2.33	**p < 0.001**
	Severe COVID-19 → Arrhythmias	HR = 1.72	**p = 0.02**

5. Discussion

5.1 Summary of Principal Findings

The study was a cohort study that included 1,000 Iraqi adults with type 2 diabetes and without diabetes (N = 500, respectively) and followed them during 12 months to assess the risk of post-COVID-19 cardiovascular disease (CVD). The cumulative burden of post-COVID CVD was 21.4% (N = 214), and that of diabetics was significantly higher (29.6, N = 148) than that of non-diabetics (13.2, N = 66) (Bansal, 2020). These results are in line with earlier studies that have indicated high cardiovascular risk in people with underlying metabolic conditions in the aftermath of SARS-CoV-2 [6,9].

Different risks were found in specific cardiovascular events. Myocardial infarction (MI) was 8.4 per cent in general and 12.0 in diabetics and 4.8 in non-diabetics. Stroke or TIA was 6.5 and 9.0 respectively in diabetics and non-diabetics. There was 4.9% overall and disproportionate heart failure (7.2% vs 2.6%). The prevalence of arrhythmias and myocarditis was also 3.6% in the participants, and in diabetics, the prevalence was greater (5.2% vs 2.0) [10,11]. These findings support the fact that the cardiovascular risk of diabetic people is two to three times greater than that of the general population, which follows the global trends of attributing the presence of metabolic dysfunction to COVID-19-associated cardiovascular issues [12,13].

Multivariate analysis has found diabetes (HR = 1.88), age above 60 (HR = 1.02/year), hypertension, and severe COVID-19 infection (HR = 2.11) to be independent predictors of post-COVID cardiovascular events. Preinfection vaccination was also effective, and it lowered the risk by 35% (HR=0.65, 95%CI=0.48-0.86, p=0.003). These results are consistent with the previous studies, which underline that extreme infection and pre-existing cardiovascular risk factors are important determinants of morbidity and mortality among COVID-19 patients [10,14].

The results also indicated that male sex and BMI were bivariately predictive of higher event rates but adjusted model results were not independent predictors. The results of the interaction testing between diabetes and the severity of COVID-19 did not show statistically significant change (p = 0.78), which might imply that the disproportionate effect of severe infection on cardiovascular outcomes in diabetic and non-diabetic patients is similar.

Overall, the main results indicate that the presence of diabetes, hypertension, age, and severe COVID-19 are significant risk factors of post-infection cardiovascular complications in Iraq and that vaccination has a considerable protective effect. The results align with the global literature of reported cardiovascular excesses and fatalities in populations with metabolic diseases during the COVID-19 pandemic [5,6,13]. The findings indicate the essential role of specific follow-up, timely cardiovascular screening and intensive management of risk factors among high-risk post-COVID groups.

5.2

Int

erpretation and Comparison with International and Regional Studies

The results of this paper indicate that post-COVID-19 cardiovascular disease (CVD) is a significant burden among the adult population in Iraq with an incidence of 21.4, and a significant higher incidence among diabetic (29.6) and non-diabetic (13.2) groups. The given pattern is consistent with the international and regional literature that repeatedly mentions diabetes mellitus, hypertension, older age, and severe COVID- 19 infection as the most important factors predetermining cardiovascular complications after the infection [8,15,16]. As in our results, Chilazi et al. [17] also indicated that patients with underlying metabolic and cardiovascular risks factors had a 23 times greater rate of cardiovascular events after COVID, myocardial infarction, stroke, and heart failure, than otherwise healthy groups.

We found that the myocardial infarction had an incidence of 8.4 percent in the whole sample and 12.0 percent in diabetics and 4.8 percent in non-diabetics, indicating that diabetics were over twice as likely to have the infarction. This level is similar to those of Matsushita et al. [18] and Aggarwal et al. [19] whose meta-analyses indicated myocardial injury in 815% of COVID-19 patients in hospitals, with greater rates among diabetic and hypertensive patients. On the same note, stroke or TIA was observed in 6.5% in all patients, and was observed in diabetics (9.0% vs. 4.0%), in line with Pranata et al. [20], who reported a 5-10% stroke or TIA rate in all COVID-19 patients and diabetes as a critical risk modifier.

Heart failure and arrhythmias/myocarditis were reported in 4.9% and 3.6% of the participants respectively with diabetics being disproportionately affected (7.2 and 5.2 respectively). This is generally in line with Chung et al. [21] and Hessami et al. [22], who then found cardiac complications in 4-10 percent of COVID-19 patients, especially those with underlying metabolic disorders. The manifestation of the disproportionality of cardiovascular events in diabetics highlights the importance of chronic systemic inflammation, endothelial dysfunction, and hypercoagulability in increasing the post-infection cardiovascular risk [15,23].

Our cohort showed a protective effect of vaccination with a 35% (HR = 0.65) decrease in cardiovascular risk, which is consistent with the observations in the region and globally. Li et al. [24] and Bae et al. [25] propose that vaccination prevents severe infection with COVID-19 and cardiovascular sequelae of the latter, which are particularly evident in the high-risk groups of diabetics and the elderly. Our results support the current evidence that vaccination is an essential intervention to prevent acute infection and also decrease post-COVID morbidity, such as cardiovascular complications.

Age-related risk comparison Age-related risk was compared, with our mean participant age of 56.8 + 11.2 years and older age related to incremental risk (HR = 1.02/year). It is not surprising considering Harrison et al. [8] and Kiss et al. [26] reported the increased incidence of CVDs in older adults, which is synergistic due to the age factor, comorbidities, and severity of COVID-19. Nonetheless, contrary to other studies in the international sphere that have found male sex to be a strong independent predictor of post-COVID CVD [17,21], our adjusted results showed no significant sex difference (HR ≈ 1.05, p = 0.72). This difference might indicate the differences between the population in the prevalence of sex-related comorbidity, lifestyle influences, or genetic predisposition.

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In terms of COVID-19 severity, patients with severe infection suffered cardiovascular incidence of 32, which equates to 14 in case of mild-to-moderate cases. This gradient is consistent with the meta-analysis results of Matsushita et al. [18] and Aggarwal et al. [19] that reported that patients with severe COVID-19 were 2-3 times more likely to suffer myocardial injury, heart failure, or a thromboembolic event. Likewise, Paramasivam et al. [16] focused on the idea that cardiovascular risk is increased by cytokine storm, endothelial dysfunction, and hypercoagulability in the case of severe infection.

On balance, our results are mostly similar to international and regional evidence and serve as strong evidence in favor of the fact that the presence of diabetes, hypertension, older age, and COVID-19 severity are the robust predictors of cardiovascular complications after infection [15,22]. A sex-related risk difference was detected, with our cohort showing no significant male predominance and it may be used to reflect population-specific epidemiology in Iraq. Considerable prospective follow-up data in our study is also robust, including a 12-month post-COVID period, which also incorporates into the literature as it features the long-term cardiovascular burden that remains after the acute infection period, and this is not as prevalent in the existing cross-sectional or short-term studies [13,23].

To sum up, the present study proves the existing trends in the world and offers specific information in regions. The target population of cardiovascular surveillance, early intervention, and vaccination is high-risk groups and specifically diabetic and hypertensive adults to decrease the long-term cardiovascular morbidity of post-COVID Iraq. The findings highlight the significance of implementing cardiovascular follow-up into the post-COVID care pathways, which is in line with the recommendations provided by systematic reviews and meta-analyses [8,17,26].

Table 5: Comparison of the Present Study Results with International and Regional Evidence on Post-COVID-19 Cardiovascular Disease

Outcome / Predictor	Our Study (Iraq, Wasit Governorate)	International / Regional Evidence	Consistency / Difference
Overall post-COVID-19 CVD incidence	21.4% of adults within 12 months	15–30% reported across cohorts and meta-analyses [14,22,23]	Consistent
CVD incidence in diabetics	29.6%	Higher risk consistently reported among diabetics (≈2–3-fold increase) [8,15,17]	Consistent
CVD incidence in non-diabetics	13.2%	Lower incidence in metabolically healthy populations (≈10–15%) [19,20]	Consistent
Diabetes as independent predictor	HR = 1.88 (95% CI: 1.42–2.49)	Diabetes identified as major independent predictor in umbrella reviews and meta-analyses [8,18]	Consistent
Myocardial infarction (overall)	8.4%	Myocardial injury or MI reported in 8–15% of hospitalized COVID-19 patients [18,19]	Consistent
MI in diabetics vs non-diabetics	12.0% vs 4.8%	Diabetics show >2-fold higher MI risk post-COVID [17,19]	Consistent
Stroke / TIA (overall)	6.5%	Stroke/TIA incidence 5–10% in COVID-19 cohorts [20,21]	Consistent
Stroke/TIA in diabetics	9.0%	Diabetes identified as major stroke risk modifier post-COVID [15,20]	Consistent
Heart failure	4.9% overall; 7.2% in diabetics	Cardiac failure reported in 4–10% of COVID-19 survivors, higher in diabetics [21,22]	Consistent
Arrhythmias / myocarditis	3.6% overall; 5.2% in diabetics	Arrhythmias reported in 3–8% post-COVID, higher with metabolic disease [21,23]	Consistent
Severe vs mild-moderate COVID-19	32% vs 14% CVD incidence	Severe disease increases CVD risk 2–3-fold [16-19]	Consistent
Age effect	HR = 1.02 per year increase	Age-related incremental risk consistently reported [8,26]	Consistent
Hypertension	HR = 1.54	Hypertension recognized as a major post-COVID CVD predictor [8,15]	Consistent

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Sex differences	No significant association (HR ≈ 1.05, p = 0.72)	Male sex often reported as higher risk in global studies [17,21]	**Different**
Vaccination effect	35% risk reduction (HR = 0.65)	Vaccination protective against severe COVID-19 and CVD sequelae [24,25]	Consistent
Follow-up duration	Prospective 12-month follow-up	Many studies short-term or cross-sectional [13,23]	**Stronger evidence**

5.3 Biological Plausibility and Mechanisms Explaining Findings

The results of this research that show an increased rate of post-COVID-19 cardiovascular disease (CVD) in diabetic patients have a high biological explanation. The incidence rate of post-COVID CVD was 29.6% in diabetic individuals in our cohort compared to 13.2 in non-diabetics, which is more than twice the risk. This increased susceptibility is explicable in several different ways that are associated with chronic metabolic dysfunction, immune dysregulation, and vascular injury [2,27].
Endothelial dysfunction, lack of bioavailability of nitric oxide, and chronic low-grade inflammation are typical features of patients with diabetes, which worsen cardiovascular stress during and after viral infections. Infection with SARS-CoV-2 triggers a systemic inflammatory effect, and levels of cytokines, including IL-6 and TNF-alpha, are increased, which additionally deteriorates vascular activity and facilitates a prothrombotic condition [24,28]. In our research, hypertension and dyslipidemia were common by 46% and 39per cent respectively among diabetics, which worsened the cardiovascular risk. These comorbidities have a synergistic effect in which the inflammatory and metabolic disturbances that are provoked by COVID-19 are enhanced, and the probability of myocardial infarction, stroke/TIA, and heart failure become more likely (12.0% vs 4.8%), stroke/TIA (9.0% vs 4.0%), and heart failure (7.2 vs 2.6) [29,30].
There are also direct viral effects on the cardiovascular system. The infection of endothelial cells by SARS-CoV-2 can cause endothelial injury, microvascular thrombosis, and myocardial inflammation [31,32]. Arrhythmias and myocarditis were also found in 5.2% of diabetics versus 2.0% of non-diabetics in our cohort, confirming the results of Ganatra et al. [33] and Ferrari et al. [34] that cardiac electrical dysfunctions and myocardial injury are notable post-infection complications. In addition, diabetics experiencing hyperglycemia could support the process of viral replication and extend inflammatory signaling, which further predisposes patients to cardiac events after COVID [35].

The effect of vaccination in the decrease of cardiovascular risk was also observed in the study, in which vaccinated people were found to be at a lower risk of post-COVID CVD (HR = 0.65, 95% CI: 0.48 0.86). Vaccination is likely to decrease the intensity of infection and the extent of systemic inflammation, which causes endothelial damage and thrombotic events [27,36]. Moreover, vaccination can minimize the occurrence of long-term viral load and cytokine storm, which are the factors contributing to the aftermath of COVID-19 cardiac diseases [2,24].
The presence of chronic comorbidity increases the risk post-COVID. CKD (14% of the diabetics in this cohort) is an independent risk factor that predisposes the patient to cardiovascular complications through volume overload, hypertension, and vascular injury associated with uremia [28]. These are the underlying pathologies that lead to the incidence of heart failure and other complications that are witnessed in diabetics. Moreover, diabetics in association with CKD and COVID-19-induced endothelial injury are likely to lead to the increased risk of CVD, which is 2-3 times beyond the risk in diabetics only (as reported by Xie et al. [2] and Dhakal et al. [31]).
Other mechanisms that have contributed to it are the dysregulation of the renin-angiotensin-aldosterone system (RAAS), which is predisposed to hypertension, myocardial fibrosis, and left ventricular dysfunction, in diabetics [32]. SARS-CoV-2 may cause an increase in the RAAS disequilibrium, caused by ACE2 downregulation that subsequently stimulates angiotensin II, vasoconstriction, and the proinflammatory response within the cardiovascular system. Moreover, lack of physical activity during infection and lockdown due to the pandemic may have worsened metabolic risk and contributed to more post-COVID cardiovascular complications [35].
There is also an inflammatory and prothrombotic basis to the increased incidences of myocardial infarction (12.0%), and stroke/TIA (9.0%) in diabetics. COVID-19 causes hypercoagulability by increasing fibrinogen, D-dimer, and platelets activation, which, combined with endothelial dysfunction existing before the outbreak and metabolic syndrome, significantly increases the risk of thrombotic cardiovascular events [2,27,30].
To sum the findings, our findings are biologically plausible, which is due to recognized mechanisms: diabetics are predisposed to endothelial damage, hypercoagulable, and with a heightened inflammatory response, which is increased by the COVID-19. Vaccination helps to eliminate these risks because it lowers the severity of the infection and the burden of inflammation. The twofold increased post-COVID cardiovascular events in diabetics (29.6% vs 13.2%) observed is consistent with mechanistic expectations and previous literature, which offer solid pathophysiological explanations of the targeted cardiovascular surveillance and early intervention of high risk populations [2,27,36].

5.4 Implications for Clinical Practice and Public Health in Iraq

This study has some critical implications to the practice and population health in Iraq. In the case of the CVD incidence rate of 21.4 in the intersection of COVID-19 survivors and 29.6 among diabetics who survived the COVID-19, there is an apparent necessity of proactive cardiovascular monitoring among COVID-19 survivors, especially among those with a history of diabetes or high blood pressure conditions [37,38]. It is necessary to identify at-risk patients with a systematic cardiovascular screening at an early stage. The screenings are supposed to involve thorough evaluation which includes ECG, echocardiography, blood pressure, HbA1c, and lipid profile analysis. As an example, 46 percent of diabetic patients had hypertension and 39 percent had dyslipidemia (which is a long-standing risk factor that can be detected and treated early to minimize complications) in our cohort [39].
It is suggested to create post-COVID follow-up clinics. Visits to these clinics can be scheduled at 3, 6, and 12 months after infection as this was modeled in this study to ensure that myocardial infarction (8.4% overall), stroke/TIA (6.5%), heart failure (4.9) and arrhythmias/ myocarditis (3.6) are detected in time. To manage the complex cases, such clinics ought to support a multidisciplinary approach, organizing internal medicine, cardiology, and endocrinology services [40]. These services may be enhanced by telemedicine platforms, especially those serving rural or resource-limited regions, allowing patients to be better served and their care continued and minimizing hospital congestion [37].

Vaccination campaigns are still one of the pillars of the intervention of the population health. The results of our study showed that vaccination led to a decrease in the risk of post-COVID-19 CVD by 35 percent (HR = 0.65, 95% CI: 0.48-0.86), which indicates the dual protective effect of vaccines against severe COVID-19 and its cardiovascular complications [38,41]. High-risk groups, including diabetic patients, the elderly, and patients with pre-existing cardiovascular conditions should be the focus of the targeted vaccination strategies. These benefits should be highlighted in public awareness campaigns but the problem of vaccine hesitancy should be also overcome in Iraq because of the impact of misinformation and the inadequate functioning of the health infrastructure [42,43].
There are also population-wide interventions that should be considered by the public health authorities to enhance the cardiovascular health literacy. The research has shown that there are knowledge gaps in the population of Iraqis about the risk factors of CVD, and that younger

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adults have a lower awareness of the management of hypertension and diabetes [44,45]. Teaching campaigns might involve community education, mass media campaigns and encompassing of primary healthcare accounts. Lifestyle counseling as a measure against diet, physical exercise, and smoking cessation is crucial, especially with the existence of post-COVID cardiovascular risk in synergy with metabolic syndrome [46].
Moreover, the comorbidity rates of post-COVID patients are high and require special attention, as 14% of them have chronic kidney disease, 46% have hypertension, 39% have dyslipidemia, which means that risk stratification tools are necessary to be included in the primary care environment to single out people who may need intensive monitoring [47,48]. These tools can help give precedence to scarce healthcare resources particularly in parts of Iraq where there is limited access to specialized services on cardiology.

Lastly, one of the implications of these findings is that they are useful in formulating national guidelines on managing long COVID cardiovascular. It may standardize post-infection care and integrate vaccination, screening, and follow-up recommendations and enhance long- term cardiovascular outcomes in Iraq [49,51]. The need to reduce the massive cardiovascular burden impending in the post pandemic COVID-19 situation in Iraq requires a concerted approach of clinical, public health, and community-based response.

5.5 Strengths and Limitations of the Study

This research has a number of strengths. To begin with, the sample size of 1,000 participants (500 diabetics and 500 non-diabetics) is sufficient to increase the statistical power and accuracy, which enables reliable estimation of the post-COVID cardiovascular outcomes [37]. Second, the planned 3, 6, and 12-month post-infection follow-up made the systematic follow-up and record incident cardiovascular events, including temporal information [38]. Third, the researchers gathered a wide range of demographic, clinical, laboratory, and imaging data to conduct powerful multivariate analyses to control the effect of numerous confounding variables, including age, sex, BMI, hypertension, dyslipidemia, and chronic kidney disease [39].
Nevertheless, there are various limitations that should be taken into consideration. The retrospective cohort aspects of the research can potentially result in the biases of recall and documentation especially of comorbidities and the severity of COVID-19 [40]. Although the multivariable regression included the adjustment of the measured confounders, unmeasured variables, including the socioeconomic status or access to medical services, cannot be eliminated [42]. The research was presented in two hospitals in Wasit Governorate, which did not allow generalizing the research to other parts of Iraq or populations with different demographic and healthcare characteristics [43,47]. Moreover, some participants were self-reported on vaccination status, and this aspect could cause misclassification bias [50].
Nevertheless, in spite of these drawbacks, the research offers useful, place-specific statistics on the risks of post-COVID cardiovascular disease and explains why diabetics are more susceptible to it and how vaccination can help them. Its results will be applicable to clinical guidelines, policies in public health, and future multicenter research in Iraq [51,52].

6. Conclusion and Recommendations

6.1 Concise Overall Conclusion

This paper shows that the risk of cardiovascular disease (CVD) increases considerably during COVID-19 infection, and especially in patients with pre-existing diabetes mellitus. The analysis of the 1,000 subjects that included 500 diabetics and 500 non-diabetics showed that 29.6 percent of diabetic patients had at least one post-COVID cardiovascular event in the past 12 months and 13.2 percent of non-diabetics patients, which is more than a two-fold difference. Myocardial infarction (8.4%), 12% in diabetics and 4.8% in non-diabetics, stroke or transient ischemic attack (6.5%), heart failure (4.9%) and arrhythmias or myocarditis (3.6) were the most common post-COVID-19 cardiovascular complications. The multivariate Cox regression analysis showed that the independent predictors of post-COVID CVD were diabetes, older age, hypertension, and severe COVID-19 infection, whereas COVID-19 vaccination was a protective factor with a significant impact (HR = 0.65, 95% CI: 0.48– 0.86, p = 0.003).
These results align with existing data on the topic reported globally, which established that already pre-existing metabolic and cardiovascular comorbidities exacerbate post-COVID cardiovascular outcomes, such as heart failure, thromboembolic events, and myocardial injury. It is worth noting that such comorbidities like hypertension (46%), dyslipidemia (39%), and chronic kidney disease (14%) were more numerous in diabetics, which complicated the risk profile. In general, the paper emphasizes the importance of organized post-COVID cardiovascular follow-up, preventive measures, and specific public health approaches to high-risk groups in Iraq due to the insufficient healthcare resources in the country and the difficulties in treating chronic diseases during the pandemic.

6.2 Practical Recommendations

The results of the present research have severe implications on the clinical practice and health of the population in Iraq by highlighting the need to develop holistic measures aimed at reducing post-COVID cardiovascular complications. Most importantly, it is the early detection of high-risk patients, particularly diabetics who showed almost 30 percent of cardiovascular events. It is necessary to implement the introduction of structured follow-up and strong vaccination programs, as well as educate the population about health.
Such interventions are required to prevent and early detect complications like myocardial infarction, stroke and heart failure that were recorded in 8.4, 6.5 and 4.9 percent of the patients respectively.

1. Cardiovascular screening in post-COVID diabetics and high-risk groups: All patients that recovered following COVID-19 with diabetes, hypertension or dyslipidemia should receive routine cardiovascular tests, such as ECG, echocardiography, HbA1c test, lipid profile, and renal tests. The results of this study suggest that diabetics were a high-risk group where 46% of individuals had hypertension, 39% had dyslipidemia, and 14% had chronic kidney disease, confirming the need to implement screening programs.
2. Enhance multi-disciplinary post-COVID cardiovascular clinics: Introduce specific clinics that will combine cardiology, internal medicine, endocrinology, nursing personnel to achieve a holistic approach to care. The use of structured follow-ups visits at a 3-, 6-, and 12-month follow- up as used in this study aids in early detection of cardiovascular events in 21.4% of patients with post-COVID CVD, provides timely means of intervention, and lowers morbidity.
3. Strengthen the COVID-19 vaccination: Vaccination in this study prevented cardiovascular risk by 35 percent, which proves the two-fold effect of both preventing severe infection and reducing the risks of long-term cardiovascular adverse consequences. The focus of the targeted campaigns needs to be on diabetic patients, elderly individuals, and patients with pre-existing cardiovascular conditions, with the additional push to educate the population on the long-term cardiovascular risks, lifestyle changes, and love of the medication regimens.
4. Standard risk stratification and follow-up procedures: National guidelines that combine risk scoring instruments to monitor post-COVID CVD can simplify the processes of monitoring in hospitals and in primary care. Systematic identification of high-risk events by 3-, 6-, and 12-month evaluations enable an optimal management of the clinical process.
5. Bring out telemedicine and community-based interventions: In rural or underserved areas, there is the idea of teleconsultation that can

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help to monitor continuously, offer lifestyle counseling, and identify complications early. Since men constituted 58 percent of the study participants and the demographics were different in the regions, remote health services increase access and quality compliance with screening and follow-up recommendations.

6. Public health education programs: Educate about the risks of cardiovascular diseases after COVID-19 on mass media, social campaigns, and community-based outreach. Specific interventions such as smoking cessation, dietary and physical exercises are especially applicable in Iraq, in which Lifestyle risk factors play a major role in the cardiovascular burden.

6.3 Suggested Avenues for Future Research and Final Statements

Future investigations ought to be done in the form of multi-center longitudinal studies in the whole of Iraq to confirm these results and to examine variations in post-COVID cardiovascular outcomes in the region. Those studies that follow-up longer than 12 months should be endorsed in order to evaluate long-term cardiovascular sequelae. It is necessary to investigate mechanisms that lead to the protective effect of the vaccination, the role of the booster doses, and the optimal management approach in the high-risk groups. Lastly, biomarker-based, imaging- based and telemedicine-based monitoring studies should be together to maximize cardiovascular complications early detection, patient outcomes, and resource allocation. Overall, this research indicates that there is a burning necessity to conduct post-COVID cardiovascular monitoring, promote vaccination, deliver care using a multi-disciplinary approach, and implement health-related policies to decrease the cardiovascular burden in Iraq and improve long-term health outcomes.

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