Integrating mental health and cardiovascular wellness: synergistic impacts and the promise of comprehensive care models

Ajeet Singh, MBBS[a], Rumaisa Riaz, MBBS[a], Amogh Verma, MBBS[b,*], Hamza Irfan, MBBS[c], Ayesha Shaukat, MBBS[a], Abdullah Nadeem, MBBS[d], Priya Goyal, MBBS[e], Ashna Habib, MBBS[a], Prakasini Satapathy, PhD[f,g]

Abstract

This review explores the bidirectional relationship between mental health disorders and cardiovascular disease (CVD), highlighting the potential of integrated healthcare models to improve outcomes. While CVD remains the leading cause of global mortality, traditionally linked to risk factors like hypertension and diabetes, emerging evidence shows that mental health conditions, especially depression and anxiety, significantly increase CVD risk through mechanisms such as chronic stress, inflammation, and neuroendocrine dysregulation. Activation of the hypothalamic-pituitary-adrenal axis and sympathetic nervous system exacerbates inflammation, elevates blood pressure, and contributes to cardiovascular risk factors. Moreover, the psychological burden of CVD often worsens mental health, creating a vicious cycle that complicates treatment adherence and patient management. Integrated care models offer a holistic approach to address these interconnected issues, potentially improving clinical outcomes, reducing healthcare costs, and enhancing patient adherence. This review also explores the role of telehealth and digital health interventions in overcoming accessibility barriers, particularly for underserved populations. Finally, policy recommendations emphasize the need for increased funding, professional training in interdisciplinary care, and targeted outreach to ensure equitable access to integrated care. By addressing both CVD and mental health challenges, these models could improve quality of life and reduce the global burden of these intertwined diseases.

Keywords: cardiovascular disease, depression, integrated care, mental health, telehealth

Introduction

Cardiovascular diseases (CVDs) are the foremost contributors to morbidity and mortality worldwide. Data from the Global Burden of Disease indicates that, in 2021 alone, these conditions were responsible for 20.5 million deaths, accounting for nearly one-third of all deaths globally[1]. CVD includes diseases such as coronary artery disease (CAD), heart attack, and strokes, and they are still the number one cause of death globally. Even

[a]Department of Internal Medicine, Dow University of Health Sciences, Karachi, Pakistan, [b]Department of Internal Medicine, Rama Medical College Hospital and Research Center, Hapur, India, [c]Department of Medicine, Shaikh Khalifa Bin Zayed Al Nahyan Medical and Dental College, Lahore, Pakistan, [d]Department of Medicine, Dow University of Health Sciences, Karachi, Pakistan, [e]Department of Internal Medicine, Dayanand Medical College and Hospital, Ludhiana, Punjab, India, [f]Development of University Center for Research and, Chandigarh University, Mohali, Punjab, India and [g]Department of Medical Laboratories Technique, AL-Mustaqbal University, Hillah, Babil, Iraq

HIGHLIGHTS

- Mental health disorders, such as depression and anxiety, not only increase the risk of cardiovascular diseases (CVD) but are also more prevalent in individuals with preexisting CVD, creating a harmful feedback loop that worsens both conditions.
- Chronic stress, inflammation, and dysregulation of the hypothalamic-pituitary-adrenal axis are key biological factors linking mental health and CVD, contributing to hypertension, atherosclerosis, and other cardiovascular issues.
- Addressing mental health and cardiovascular health together through integrated care models has shown potential for improving patient outcomes, yet significant knowledge gaps remain in implementing and optimizing these approaches effectively.
- Studies consistently demonstrate the higher prevalence of mental health disorders in CVD patients, and vice versa, with clinical evidence suggesting that treating mental health conditions can improve cardiovascular outcomes, highlighting the need for comprehensive treatment strategies.

though the part played by conventional risk factors, including hypertension, diabetes, and obesity, has been thoroughly researched, it is now realized that they are not sufficient to explain the high incidence of CVD. Promising evidence currently exists on the bi-directional significant associations of mental health disorders with cardiovascular health, which indicates the interconnectedness of these health domains that have not

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

to date been effectively captured by integrated models of medicine[2]. This review aims to explore this interconnection and assess how integrated healthcare models can enhance patient outcomes by addressing both conditions simultaneously.

Although research has established the association between mental health and CVD, a significant gap remains in understanding the most effective strategies for managing both conditions in a unified manner. Current healthcare approaches often treat these issues separately, leading to fragmented care and suboptimal health outcomes. The absence of standardized, multidisciplinary interventions highlights the need for research that consolidates findings from both fields to propose holistic treatment strategies. Identifying and addressing this research gap is crucial to developing evidence-based interventions that integrate mental health support into cardiovascular treatment protocols.

Depression and anxiety disorders are already recognized as essential factors that have shifted from the role of "less threats" to the leading global burdens of disease[3]. Depression is a universal condition that affects more than 280 million people globally, while anxiety disorders, which are also common among the population, affect millions of people regardless of their age, gender, or economic status, for instance. These mental health issues are not only psychological but are evident in other forms that directly affect the biological processes that are areas of cardiovascular systems[4]. For instance, depression is associated with raised inflammation and disturbances of the hypothalamic-pituitary-adrenal (HPA) axis, both of which are detrimental to CVD. Patients with anxiety disorders have a constantly stimulated sympathetic nervous system, which results in high blood pressure, increased pulse rate, and high stress hormone levels – all of which fall under the category CVD risks. The relationship between mental and CVDs has gone from a hypothetical connection to a well-developed research area since it has been demonstrated how these diseases can enhance each other[5].

Adding complexity to this relationship is the recognition that the link between mental health and CVD is bidirectional[6]. Patients with preexisting CVD are commonly privy to heightened prevalence rates of mental health disorders caused by the psychological effects of the disease, stress related to chronic illness, as well as decreases in lifestyle flexibility as a result of their disease[5]. This creates a feedback loop: mental illness increases CVD risk, and CVD, conversely, increases the likelihood of poor mental health. This cycle, as described, damages not only patient outcomes but also hurts overall health systems and economies across the globe. For example, the following patients are likely to display challenges in following prescribed treatment plans, managing their diet, and gaining access to medical care to reverse sickness and overall health deterioration: patients with dual mental and cardiovascular disorders[2].

Recent literature points to the view that integrated care models are viable while at the same time establishing that significant knowledge deficits persist in this field. Thus, more extensive research efforts are necessary to refine procedures, define effective practices, and introduce such models successfully into various healthcare environments.

This review contributes uniquely by synthesizing insights from cardiology, psychiatry, and pharmacology to propose an integrated care model. By analyzing key interactions between mental health and CVD, this research provides actionable insights that may guide future clinical guidelines and healthcare policy reforms. Unlike prior research that primarily examines

these conditions in isolation, this review emphasizes a holistic perspective, demonstrating the necessity of a collaborative and interdisciplinary treatment framework. By addressing these critical gaps, this research aims to improve long-term patient outcomes through a more unified and systematic healthcare approach.

The intersection of mental health and cardiovascular health

Biological mechanisms

Stress response and cardiovascular health

Role of the HPA axis
The HPA axis is a complex network of neuroendocrine channels and feedback loops that regulate physiological homeostasis. It is well documented that humans and animals cope with stressors to their welfare by activating neurons that regulate neuroendocrine and autonomic responses[7]. The adrenal cortex secretes glucocorticoids, an identifiable feature of the endocrine response for the HPA axis. To maintain homeostasis, circulating glucocorticoids act on different kinds of tissues by limiting reproduction, inducing lipolysis and proteolysis, amplifying sympathetic nervous system-driven vasoconstriction, and changing stress-related behaviors[8]. Most acute stress responses, such as enhanced metabolism, cognition, and immune suppression, provide a survival advantage. However, prolonged or repeated stress exposure can lead to dysregulation of the HPA axis, resulting in chronically elevated cortisol levels that contribute to metabolic syndrome, insulin resistance, and central obesity – all of which are key risk factors for CVD[9]. Chronic activation of the HPA axis also induces glucocorticoid resistance in immune cells, impairing their ability to regulate inflammatory responses, thereby promoting low-grade systemic inflammation[9]. This persistent elevation in circulating glucocorticoids is associated with systemic inflammation, oxidative stress, endothelial dysfunction, and increased risk of metabolic disorders such as insulin resistance, obesity, and hypertension, all of which contribute to CVD[9]. Dysregulation of the HPA axis has physiological knock-on effects that eventually increase the risk of immune system problems, depression, metabolic diseases, and CVDs such as cardiac hypertrophy and vascular damage[9] (Fig. 1).

Impact of chronic stress on cardiovascular risk factors
Prolonged stress exposure has been linked to hypertension, atherosclerosis, and other cardiovascular disorders. Prolonged stress causes the sympathetic adrenal medulla to become more active, lowers the hypothalamus-pituitary-adrenal axis activity, decreases anti-inflammatory capacity, and raises blood catecholamine levels[10]. By binding to the β-adrenal receptor on macrophage surfaces, catecholamine encourages the production of additional catecholamine by macrophages, triggering a cascade of inflammatory responses and accelerating atherosclerotic plaque formation[11–13]. Additionally, chronic stress promotes oxidative stress, which contributes to vascular dysfunction. Excessive production of reactive oxygen species due to prolonged stress damages endothelial cells, reduces nitric oxide bioavailability, and impairs vasodilation, ultimately leading to arterial stiffness and hypertension[14,15]. Over time, this imbalance predisposes individuals to hypertension, myocardial infarction, and stroke. Even if
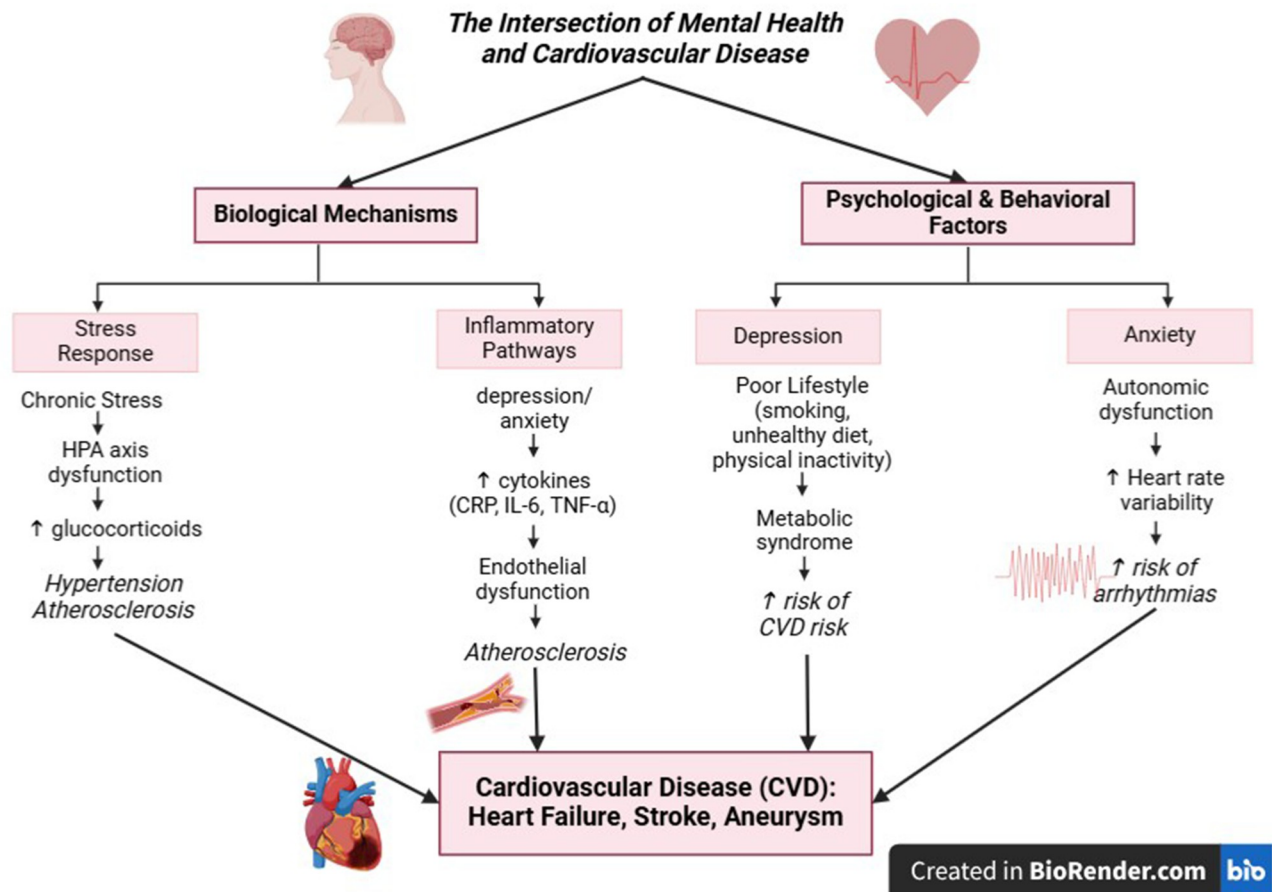
Figure 1. Mental health disorders as risk factors for cardiovascular disease. HPA axis, hypothalamic-pituitary-adrenal; CRP, C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor alpha; CVD, cardiovascular disease.

there is ongoing debate over this association, epidemiological research suggests the significance of psychological stress in the pathology of essential hypertension[16–21]. Research indicates that chronic stress can precipitate various cardiovascular conditions, including the dysfunction of vascular smooth muscle cells and an elevated risk of aneurysmal rupture[22–25]. Critically, persistent stress is a crucial factor in the initiation and progression of atherosclerosis. According to another research, Mexican women's carotid atherosclerosis is independently associated with long-term stress[26]. After 2 weeks of chronic stress in the rat model of atherosclerotic intimal hyperplasia, atherosclerotic lesions obstruct most of the carotid arteries[27]. A large cohort study of over 10 000 people discovered that one or more degrees of psychological stress were considerably higher in myocardial infarction patients[28]. The overwhelming data from both human and animal studies emphasizes chronic stress's importance in enhancing CVD advancement, particularly atherosclerosis.

Inflammatory pathways

Influence of mental health disorders on systemic inflammation
The relationship between inflammation and depression is apparent[29]. Patients with significant depression consistently show elevations in immune markers linked with chronic inflammation, such as tumor necrosis factor, interleukin (IL)-1 beta,

and interleukin-6 (IL-6), as well as acute phase proteins like C-reactive protein (CRP)[30]. Postmortem brain samples from depressed people additionally demonstrate increased inflammatory responses, including microglia activation, immune cell trafficking to the brain, and activation of inflammatory signaling pathways in the brain parenchyma[30]. Furthermore, the administration of inflammatory stimuli like endotoxin and the typhoid vaccine, as well as inflammatory cytokines like interferon-alpha, can cause depressed symptoms. The emergence of depressive disorders is predicted by inflammatory indicators such as CRP and IL-6[30]. Lastly, suppression of inflammatory cytokines has been demonstrated to lessen depressed symptoms, particularly in individuals with inflammatory and autoimmune diseases[31,32]. It has been demonstrated that inhibiting inflammatory cytokines might lessen depressed symptoms, particularly in those with inflammatory and autoimmune diseases[31,32] (Fig. 1).

Connection between inflammation and CVD
Systemic and localized inflammatory processes are essential factors in the onset and progression of CVD, affecting stages from endothelial dysfunction to the presentation of clinical symptoms[33–36]. It has been demonstrated that inflammatory biomarkers can predict CVD without referencing typical risk factors[37–40]. A common mechanism connecting preexisting and emerging cardiovascular risk factors to the development of

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

atherosclerosis, which causes cerebral aneurysms, major artery thrombotic stroke, and CAD, is inflammation[41–45]. All stages of atherosclerosis, from atherogenic lipoprotein retention within the arterial wall to plaque development and rupture, involve a complex network of both innate and adaptive immune systems, including the bone marrow and spleen, which modulate the pro-inflammatory and anti-inflammatory responses of protein mediators such as cytokines and immune cells such as leukocytes, macrophages, and lymphocytes[46]. Sympathetic activation caused by mental stress increases the risk of heart failure (HF), accelerates the development of atherosclerosis, and destabilizes plaque[47–52].

The sympathetic nervous system's activity also induces platelet activation in response to mental stress. Elevated coagulability and a prothrombotic condition are caused by activated platelets releasing inflammatory cytokines and adhesive molecules that cause leukocyte recruitment on the endothelium surface. Consequently, these circumstances facilitate the attraction of leukocytes and platelets to the vessel wall, thereby encouraging the onset of arterial thrombosis[5,48,53]. Hence, the onset and progression of CVD are influenced by inflammation and sympathetic activity, underscoring the complex relationship among stress, immunological responses, and cardiovascular risk.

Neuroimmune and neurovascular interactions

Imbalances in the brain's immune response associated with mental health disorders contribute to persistent neuroinflammation, which negatively impacts vascular function. Stress plays a crucial role in the complex interplay between the neuroendocrine and immune systems, leading to adverse physiological effects. Psychological distress activates the HPA axis and the sympathetic nervous system, initiating inflammatory pathways that elevate cardiovascular risk. Furthermore, stress-induced immune system changes promote chronic low-grade inflammation, a factor implicated in both psychiatric disorders and CVDs. Increased levels of inflammatory markers such as IL-6 and CRP serve as indicators of CVD risk while also being strongly associated with depressive symptoms, highlighting a shared underlying mechanism[53].

Amygdala overactivity and arterial inflammation
Excessive activation of the amygdala, frequently seen in individuals with chronic stress and anxiety disorders, is closely linked to systemic inflammation and vascular dysfunction. Heightened amygdala activity corresponds with increased arterial inflammation, accelerating the onset and progression of CVD. This overactivity prompts the bone marrow to produce pro-inflammatory immune cells, which migrate into blood vessels and contribute to atherosclerosis. The inflammatory response triggered by chronic stress serves as a critical link between mental health disorders and CVD progression[5].

Psychological and behavioral factors

Depression and cardiovascular risk

Prevalence of depression in cardiovascular patients
Depression affects around 20% of individuals with CAD and may increase to 30%–40% in those with HF[54–59]. Over the past few decades, there has been a twofold increase in the prevalence of depression among patients with cardiovascular disorders[60].

Moreover, patients with myocardial infarction or HF had a threefold increased incidence of depression compared to the general population[61,62].

Depression's impact on lifestyle choices and adherence to treatment
Patients with CVD and depression have been shown to have poor quality of life in developing countries[63,64]. Patients' work, social lives, and lifestyle choices are all impacted by depression. It could also affect their productivity, adding to the stress on their families[64], resulting in hospital readmissions and raising the mortality rate from coronary heart disease (CHD)[65,66]. Patients with depression are less likely to adhere to healthy lifestyle habits and self-care regimens[66], which increases their risk of developing CAD. Additionally, several research studies have shown that depressed patients adhere to medication and lifestyle modifications less well, which harms their medical conditions[67–69].

Additionally, depression has been linked to higher rates of smoking and lower likelihood of cessation[70,71], higher rates of physical inactivity[69–71], higher rates of alcohol consumption[70], and higher rates of dietary fat intake[71]. On the other hand, because of their increased physical activity, individuals with CAD who exhibit positive effects have more excellent survival rates[72,73]. Moreover, a patient's adherence to healthy living practices is gradually linked to increased positive impact[73] (Fig. 1).

Anxiety and cardiovascular outcomes

Relationship between anxiety disorders and cardiovascular events
Anxiety disorders are among the most prevalent psychological disorders, with severe symptoms, a high clinical burden, and challenging treatment options[74]. Studies have indicated a strong correlation between anxiety disorders and heart disease[75]. In addition, anxiety disorders themselves are a separate risk factor for death and morbidity related to CVD[76,77]. The patient's general health might decline because of the interaction between these two disorders[78]. Thus, to inform preventative and therapeutic approaches, it is imperative to investigate the relationship between anxiety disorders and CVD.

Anxiety's effect on heart rate variability and overall cardiac function
Numerous studies have repeatedly shown that people with anxiety have higher levels of inflammatory markers like homocysteine, CRP, and IL[79,80]. As a result, anxiety disorders can cause long-term inflammation, which can damage blood vessel endothelial linings and increase the risk of heart attacks and strokes[81,82]. Anxiety affects the cardiovascular system through a complicated autonomic circuit that includes the autonomic nerve system and anxiety-related nuclei[83]. Anxiety disorders can cause psychological stress, which can activate the HPA axis and the sympathetic nervous system. This can lead to elevated levels of cortisol, catecholamines, and other hormones, which may degrade atherosclerotic plaques and ultimately cause thrombosis, which is the primary root cause of acute coronary syndromes[84–86]. Moreover, anxiety disorders may increase the risk of HF and unfavorable consequences by limiting the cardioprotective effects of B-type natriuretic peptide mediated by the vagus[87]. All these results lead to a likely relationship between anxiety disorders and heart disease (Fig. 1).

Evidence of synergistic impacts

Epidemiological evidence

Co-occurrence of mental health disorders and CVD

For those with severe mental illnesses (SMI), CVD is the leading cause of death, just like it is in the general population[88–90]. The most thorough meta-analysis of CVD risk in individuals with SMI to date, which included 113 383 368 controls and 3 211 768 patients, found that SMI patients had a statistically significant higher risk of CHD overall compared to controls (54% higher risk in longitudinal studies and 51% higher risk in cross-sectional studies)[91]. Patients with congestive HF experience depression at a much higher rate than those in the general population[92]. Up to one-third of CHD patients have heightened depressive symptoms, and over one-fifth of all patients have depression (the risk of depression is highest in the most severe CHD cases). These are at least four times higher prevalence than those found in the population[93–95]. At the same time, depression is more common in women than in men with established congestive HF; depression in males is more strongly associated with a worse prognosis for the heart[96]. A meta-analysis of 30 prospective cohort studies (N = 893 850) found that there is a statistically significant 30% (relative risk [RR] = 1.30, 95% CI: 1.22–1.40) increase in the risk of CHD among those who have depression as opposed to those who do not[97]. In comparison to nondepressed individuals, depression was linked to a 31% greater likelihood of the risk of MI and a 36% increase in the risk of cardiovascular mortality, according to another meta-analysis of prospective cohort studies (N = 323 709)[98]. Despite not finding a higher risk of CHD in those with bipolar disorder (BPD)[91], the most thorough meta-analysis of CVD risk in people with SMI did discover a substantial correlation between BPD and CVD in longitudinal studies. In the past 10 years, three meta-analyses[65,88,89] have supported the findings of previous research indicating a possible link between anxiety disorders and incident CHD. One of them shows that anxiety is linked to a 41% increased risk of CHD[76]. Comparatively, to general/unspecified anxiety, phobic anxiety had a stronger correlation with incident CHD. Independent of demographics, biological risk factors, and health behaviors, another meta-analysis of 20 studies (N = 249 846) examining the relationship between anxiety (i.e. anxiety, panic, phobia, and anxiety) and incident CHD found that at first, healthy individuals with high anxiety had a 26% higher risk for incident CHD (hazard ratio [HR] = 1.26, 95% CI: 1.15–1.38, P > 0.0001)[99]. Depending on the diagnostic technique used, the prevalence of Post Traumatic Stress Disorder caused by heart disease varies greatly, ranging from 0% to 38%, with an average of 4%–16%, according to a recent systematic review that included 150 research[100]. A large-scale Swedish study (N = 1 107 524) revealed that there is a correlation between mental illness and CHD for a variety of mental disorders, such as personality disorders, alcohol-related disorders, adjustment disorders, and other substance use disorders, with increased CHD risks ranging from 35% to 92% when compared to individuals who did not receive a diagnosis for the disorder in question[101]. Shen et al[102] stated the crude incidence rate of CVD as 9.7, 7.4, and 7.0 per 1000 person-years among patients with psychiatric illnesses, their unaffected siblings, and the matched reference group throughout up to 30 years of follow-up of the Swedish cohort. In comparison to their siblings, patients with psychiatric illnesses had higher rates of CVD during the first year following diagnosis (HR, 1.88; 95%

confidence interval [CI], 1.79–1.98) and beyond that (1.37; 95% CI, 1.34–1.39). This was according to longitudinal matched cohort research. Comparing the rate increases with the matched reference population revealed similar trends[102]. Because of the firm and conclusive link between mental health issues and CVD highlighted by epidemiological data, these susceptible individuals must receive integrated treatment approaches that address their mental and cardiovascular health.

Clinical evidence

Impact of mental health treatment on cardiovascular outcomes

Numerous research studies have investigated how treating anxiety and depression affects cardiovascular outcomes (Table 1). Wu et al[103] observed 7419 post-MI patients from a Taiwanese registry and discovered a j-shaped distribution of outcomes: patients on low doses of benzodiazepines experienced reduced rates of hospitalizations for HF, cardiovascular mortality, and sudden death; however, at higher doses, the benzodiazepines lost their protective effects and were linked to an increased risk of sudden death. Patients treated with benzodiazepines as opposed to non-benzodiazepine Z-drugs showed a trend toward increased mortality and a greater likelihood of rehospitalization in a trial of HF patients with insomnia[104]. To better understand the effects of benzodiazepines on the HF population and the impacts of anxiety on HF patients, more research is required. According to a study by Carmin et al[105], receiving mental health treatment for depression or anxiety – whether through medication or psychotherapy – was linked to a notable and significant decrease in the risk of either an emergency department (ED) evaluation (74% risk reduction if receiving both treatments, 49% for medication treatment alone, and 53% for psychotherapy alone) or a being readmitted to the hospital (75% risk reduction if receiving both treatments, 49% for psychotherapy alone, and 58% for medication alone). According to these results, mental health therapies are crucial for lowering ED visits and hospital stays in patients with concomitant anxiety or depression and HF [105,106]. Some studies have evaluated secondary endpoints associated with the disease outcome. For example, SADHART-CHF (Sertraline Against Depression and Heart Disease in Chronic HF)[107,108] found a trend toward fewer hospitalizations for HF patients receiving depression treatment. The exact processes via which mental health interventions are linked to decreased rates of ED visits, hospitalizations, and overall mortality are still unknown. Nonetheless, these results align with the present comprehension of the heart-brain link.

Impact of cardiovascular treatments on mental health

Beta-blockers, lipid-lowering medications, angiotensin-converting enzyme (ACE) inhibitors, diuretics, and antiarrhythmics are frequently recommended to patients with heart conditions to address their underlying cardiac conditions. There is continuous discussion about the potential drawbacks of these treatments[109], even with their well-established advantages, which include increased survival rates in patients with HF[110], myocardial infarction, and arrhythmias[111]. For example, poorer psychological functioning is believed to be linked to the process by which lipophilic beta-blockers, such as metoprolol, damage the blood-brain barrier[112]. Moreover, 15% of

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

Key studies supporting the findings on mental health and cardiovascular disease

Study	Main findings	Results	Key interactions
Wu *et al*, 2014	Moderate doses of anti-anxiety medication improve cardiovascular outcomes, while higher doses increase risks.[104]	A J-curve effect was observed: low to moderate benzodiazepine (BZD) doses reduced cardiac mortality and heart failure hospitalization, but higher doses (>5 mg/day) increased sudden death risk.[104]	Mental health management can positively influence cardiovascular outcomes, highlighting the need for integrated care models.[104]
Sato *et al*, 2020	Benzodiazepine use in heart failure patients with insomnia increases rehospitalization risk compared to Z-drugs.[105]	Patients on benzodiazepines had a 1.5-fold higher risk of rehospitalization for heart failure than those using Z-drugs.[105]	Optimizing insomnia treatment in heart failure patients may help reduce hospital readmissions.[105]
Carmin *et al*, 2024	Mental health treatment significantly reduces hospital readmissions and mortality in heart failure and ischemic heart disease patients.[106]	Patients receiving both psychotherapy and antidepressants had 75% fewer rehospitalizations, 74% fewer emergency visits, and 66% lower mortality.[106]	Integrating mental health treatment into cardiovascular care improves patient outcomes.[106]
Jiang *et al*, 2011	Depression remission in heart failure patients is associated with fewer cardiovascular events and better survival.[108]	Patients whose depression remitted had significantly lower cardiovascular events and longer survival than those whose depression persisted.[108]	Treating depression in heart failure patients may improve cardiovascular prognosis.[108]
Rotvig *et al*, 2022	Cardiac drug therapies, especially beta-blockers and antiarrhythmics, are linked to increased anxiety in cardiac patients.[123]	Patients using beta-blockers, antiarrhythmics, and diuretics had significantly higher self-reported anxiety symptoms.[123]	Neuropsychiatric side effects of cardiac drugs should be considered in managing mental health and cardiovascular disease together.[123]
Zhang *et al*, 2022	Certain cardiovascular drugs, including diuretics and calcium channel blockers, increase depression and anxiety risk.[122]	Diuretics, nitrate esters, and calcium channel blockers were associated with higher depression and anxiety risks, while aspirin and statins had protective effects.[122]	Mental health assessments should be integrated into long-term cardiovascular medication management.[122]
Thompson *et al*, 2014	Anxiety and depression worsen symptom perception in atrial fibrillation patients.[117]	Increased anxiety and depression worsened atrial fibrillation symptoms, even after treatment with catheter ablation or antiarrhythmic drugs.[117]	Psychological interventions may improve overall symptom relief in AF patients.[117]
Huffman and Stern, 2007	Cardiovascular medications can cause neuropsychiatric side effects, including depression and anxiety.[110]	Beta-blockers, diuretics, and ACE inhibitors have been linked to increased depression and fatigue, while calcium channel blockers and propranolol have potential anxiolytic benefits.[110]	Careful selection of medication is crucial to balance cardiovascular benefits with mental health risks.[110]

ACE inhibitors, angiotensin-converting enzyme inhibitors; AF, atrial fibrillation; BZD, benzodiazepine.

individuals on the antiarrhythmic medication amiodarone have been found to have thyroid abnormalities, which can result in mood, cognitive, and psychotic symptoms[113–115]. The present number of primary research examining the relationship between cardiac medication therapy and the likelihood of experiencing anxiety symptoms is contradictory and founded on limited sample sizes[116–120]. According to a meta-analysis, individuals with CVD should have their use of cardiac medications considered when assessing their anxiety and depression[121]. In the Rotvig *et al*[122] study, 2891 (32%) of the 8998 respondents reported having anxiety symptoms. Digoxin, antiarrhythmics, beta-blockers, ACE inhibitors, and angiotensin receptor antagonists have all been linked to neuropsychiatric adverse effects[122]. To maximize patient results, it is essential to carefully weigh the advantages of cardiac drugs against any potential mental health risks, as these effects may impact psychological well-being.

Integrated care

Integrated care, also known as integrated health or coordinated care, is a transformative approach to healthcare, especially in psychiatric and physical health problems[123]. This model aims to improve patient satisfaction and clinical status by facilitating coordination between caregivers, especially for chronic diseases like depression and CVDs[124]. Integrating personal care is founded on recognizing that mental and physical health are closely interconnected, significantly influencing the other's

condition. For example, people with serious mental illnesses (SMIs) such as schizophrenia have more vulnerability to developing CVD, which can be negatively affected by other lifestyle choices such as excessive intake of fatty foods and a sedentary lifestyle[125]. Hence, implementing mental health services within primary care can enhance the identification of clinical risk factors for CVD and subsequently improve outcomes[126].

There is ample evidence supporting the effectiveness of integrated healthcare models; for instance, combining the care of diabetes and depression can improve a patient's outcomes significantly since depression is correlated to cardiovascular health[127]. Studies have shown that collaborative care models have been successfully implemented across different levels of care. For instance, a combination of mental health and diabetes care in residential programs has had a favorable result on people with SMIs[128]. Furthermore, the Veterans Affairs healthcare system has also utilized integrated care models to support and treat multiple somatoform disorders, depression, post-traumatic stress disorder, and other physical or medical conditions that veterans present with, and this has led to enhanced treatment retention and overall health[129].

The evidence supporting collaborative care extends beyond individual case studies. Several systematic reviews have also demonstrated the efficacy of integrated care in managing behavioral, mental, and physical health outcomes across various populations[130]. For example, a published systematic review of integrated chronic care models described seven studies. It concluded that these models could increase access to care, improve

treatment quality, and facilitate the management of co-morbid conditions with little or no increase in cost[130].

Furthermore, interventions like the Behavioral Health Home (BHH) model have been developed to provide coordinated care for people with SMI, including cardiovascular risk reduction. The BHH model focuses on integrating behavioral health services with primary care to improve overall health outcomes. While one study demonstrated some benefits in cardiovascular health in patients with chronic diseases, the results differ from another study that has revealed little or no changes whatsoever[131,132]. Recent research also highlights the Health Outcomes Management and Evaluation Study, which tested an integrated behavioral health home model and showed promising results in addressing both physical and mental health needs. The model was particularly effective in improving metabolic outcomes in individuals with SMIs, though challenges remain in long-term sustainability[131]. Additionally, lifestyle interventions tailored for individuals with SMIs, such as those implemented in the InSHAPE program, have demonstrated benefits in reducing cardiovascular risk factors through structured physical activity and nutritional guidance[125].

Furthermore, a functional medicine approach to integrated care emphasizes personalized treatment plans that address both psychological and physiological aspects of chronic illness. This approach has been shown to enhance patient engagement and long-term adherence to treatment[123]. Despite these advancements, barriers such as healthcare system fragmentation, financial constraints, and disparities in access continue to limit the widespread implementation of integrated care models. Addressing these challenges requires stronger policy support, increased provider training, and improved care coordination strategies.

Patient-centered medical home and telehealth

The Patient-Centered Medical Home (PCMH) model is another model of care that has also been deemed helpful in managing chronic diseases, including mental and cardiovascular disorders. It is a new model of care that focuses on whole-person orientation, coordinated and accessible healthcare for patient needs[133,134]. The structure of PCMH is defined by teamwork, in which primary care providers collaborate with physicians, specialists, nurses, and other workers from different specialties. The collaborative model has been effective in increasing health standards, increasing patient satisfaction levels, and bringing down the costs of healthcare[133].

Evidence shows that PCMHs can reduce hospitalization rates and ED utilization in patients with long-term diseases[135]. For example, a study demonstrated that elderly patients receiving PCMH services had better control of chronic diseases, improving their overall health and decreasing their healthcare utilization[136]. This is beneficial for the patients in that it can significantly reduce the cost and time involved in an in-person visit to a healthcare provider.

It has also become apparent that telehealth and other digital approaches constitute essential elements of chronic conditions care delivery during and after COVID-19[137]. Telehealth leads to equal access to all that can be done through remote consulting, hence eliminating the need for the patient to access the healthcare provider physically; this is of great advantage to patients with mobility problems or patients in areas with limited access to healthcare providers[138]. A systematic review, including studies using telehealth services in CVD management, showed the effectiveness of these services in enhancing results such as blood pressure regulation and reduced hospitalization rates[139]. Telehealth services can complement the PCMH model because it is proven to facilitate care coordination and guarantee that the patient will receive all the necessary help at the right time, consequently championing the management of chronic diseases.

Telehealth has also proven to be a viable option for mental health, where most people struggled to get access to therapy due to the COVID-19 outbreak[140]. It is noted that tele-psychological services are popular among the rural population because, after the reception, many patients state an increase in satisfaction and the absence of social stigma for receiving mental treatment by turning to a specialist through the internet[141]. Digital health also entails mobile apps and online platforms for therapy and has also been identified to increase attendance and compliance with clinical management programs for mental health illnesses[142].

The efficacy of digital health tools and remote monitoring in managing chronic conditions cannot be overstated. A longitudinal study demonstrated that patients with chronic CVDs who utilized a fourth-generation telehealth program experienced lower hospitalization rates and reduced healthcare costs than those receiving traditional care[143]. Telehealth interventions for secondary prevention of CHD have similar outcomes to traditional rehabilitation programs. They have been shown to improve exercise capacity, reduce mortality rates, and enhance overall quality of life[144]. These results demonstrate the potential of telehealth to improve chronic disease management and patient outcomes.

Challenges and future recommendations

Integrating care adds value because it focuses on delivering healthcare products through the organization and coordination of different parts of patient care delivery. However, there are significant challenges to the effective implementation of integrated care. Such barriers can be grouped as systemic/structural and patient-level barriers." This article helps identify some of the obstacles to this process and thus informs the necessary changes to deliver efficient care to patients with CVDs.

Systemic and structural barriers primarily stem from the fragmentation of healthcare systems. Fragmentation occurs when different healthcare providers and services operate independently, leading to disjointed patient care experiences[145]. This lack of coordination can result in patients receiving incomplete or conflicting information about their health conditions, which is particularly detrimental for those with chronic diseases such as cardiovascular conditions[146]. Financial limitations add to these problems; many healthcare systems need help affording the investment required for integrated care. A national survey indicated that budget issues significantly reduce the benefits of teamwork between health professionals in these programs[147]. Additionally, scheduling conflicts, transportation barriers, and other logistical obstacles can limit patient access to healthcare services[148]. These barriers contribute to treatment delays and insufficient management, ultimately leading to poorer health outcomes.

At the patient level, barriers such as reluctance and stigma can significantly impact the effectiveness of integrated care. Many patients may feel hesitant to engage with healthcare services due

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

to previous negative experiences or societal stigma associated with certain health conditions, including CVDs[149]. This reluctance can prevent patients from seeking timely care or adhering to treatment plans, which is crucial for managing chronic conditions effectively. Furthermore, stigma can deter patients from discussing their health concerns openly with providers, leading to miscommunication and inadequate care[149].

Future research should address critical gaps in understanding integrated care models, particularly in their long-term impact on mental and physical health outcomes across diverse populations. Longitudinal studies are needed to evaluate how these models affect patient health over extended periods, providing insights into sustainability and effectiveness. Additionally, cost-effectiveness analyses can elucidate the financial implications of implementing integrated care, particularly those incorporating telehealth and digital interventions, demonstrating their value to policymakers and healthcare providers. Furthermore, enhancing the understanding of patient experiences and satisfaction will be crucial in refining care delivery, while investigating how integrated care can mitigate health disparities in underserved communities is vital for promoting equitable access.

Policymakers should explore several strategic steps to enhance the implementation of integrated care models. First, increased funding for collaborative care initiatives can support integrating mental and physical health services within healthcare systems. Financial incentives for healthcare providers participating in these models can encourage adoption and adherence to integrated practices. Additionally, investing in training programs for healthcare professionals on inter-professional collaboration and communication is essential to enhance care coordination. Addressing systemic barriers, such as administrative challenges and financial constraints, is necessary to create a more cohesive healthcare environment. Lastly, developing targeted outreach programs to engage communities, particularly those in rural or underserved areas, will facilitate better access to integrated care and ensure patients receive the comprehensive services they need.

Limitations of the work

This review acknowledges some limitations. Observational studies rather than randomized controlled trials were used, restricting causal inference between mental health disorders and CVD. Differences in study methodology, population demographics, and diagnostic criteria affect the generalizability of findings. Moreover, the lack of longitudinal data prevents understanding the long-term effects of integrated care models.

Although attempts have been made to control them, sociodemographic variables such as lifestyle and socioeconomic status may still influence the effect observed. It may also be limited in its coverage of new developments related to digital interventions and telehealth. Other systemic barriers, including those related to healthcare infrastructure and finance, remain poorly understood yet could fundamentally affect research findings.

Most studies focus on specific geographical areas, limiting the generalization of these findings to subpopulations. Future research addressing these limitations will better inform the implementation of integrated healthcare approaches for mental and cardiovascular health.

Conclusion

In conclusion, the intricate bidirectional relationship between CVD and mental health disorders demands a nuanced and integrative approach to patient care. Mental health conditions such as depression and anxiety not only exacerbate the risk of CVD through physiological pathways like inflammation and stress response but also complicate recovery and management for those already suffering from CVD. Conversely, CVD often leads to significant psychological stress, further compounding patients' health challenges and creating a feedback loop that worsens outcomes on both fronts. The evidence highlights the significance of integrated care models that address mental health and cardiovascular conditions, demonstrating benefits in patient adherence, reduced hospitalizations, and improved health outcomes. Successfully implementing these models, however, involves tackling challenges such as disjointed healthcare systems, logistical hurdles, and societal stigma. Future research should focus on enhancing integrated care methods and exploring digital health innovations to ensure accessible and coordinated care, especially for underserved populations. These initiatives are vital for progressing toward a comprehensive, patient-centered healthcare system that recognizes the close connection between mental and cardiovascular health.

Ethical approval

No ethical approval was required for this study design, as all data were obtained from publicly available sources.

Consent

Informed consent was not required for this narrative review article.

Author contributions

Conceptualization, writing original draft preparation, writing–reviewing and editing: A. Singh; conceptualization, writing original draft preparation, writing–reviewing and editing: R.R.; conceptualization, writing original draft preparation, writing–reviewing and editing: A.V.; conceptualization, writing original draft preparation, writing–reviewing and editing: H.I.; conceptualization, writing original draft preparation, writing–reviewing and editing: A. Shaukat; conceptualization, writing original draft preparation, validation: A.N.; conceptualization, writing original draft preparation: P.G.; conceptualization, writing original draft preparation: A.H.; supervision and validation: P.S.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research registration unique identifying number (UIN)

Not applicable.

Guarantor

Ajeet Singh and Amogh Verma.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Data availability statement

Not applicable.

Acknowledgements

The authors have no acknowledgments to declare.

References

[1] Lindstrom M, DeCleene N, Dorsey H, et al. Global burden of cardio-vascular diseases and risks collaboration, 1990-2021. J Am Coll Cardiol 2022;80:2372–425.

[2] Borkowski P, Borkowska N. Understanding mental health challenges in cardiovascular care. Cureus 2024;16:e54402.

[3] Yang X, Fang Y, Chen H, et al. Global, regional and national burden of anxiety disorders from 1990 to 2019: results from the global burden of Disease Study 2019. Epidemiol Psychiatr Sci 2021;30:e36.

[4] Kubzansky LD, Huffman JC, Boehm JK, et al. Positive psychological well-being and cardiovascular disease. JACC Health Promotion Series J Am Coll Cardiol 2018;72:1382.

[5] De Hert M, Detraux J, Vancampfort D. The intriguing relationship between coronary heart disease and mental disorders. Dialogues Clin Neurosci 2018;20:31–40.

[6] Li X, Zhou J, Wang M, et al. Cardiovascular disease and depression: a narrative review. Front Cardiovasc Med 2023;10:1274595.

[7] Zuloaga DG, Heck AL, De Guzman RM, et al. Roles for androgens in mediating the sex differences of neuroendocrine and behavioral stress responses. Biol Sex Differ 2020;11:1–18.

[8] Papadimitriou A, Priftis KN. Regulation of the hypothalamic-pituitary-adrenal axis. Neuroimmunomodulation 2009;16:265–71.

[9] Sheng JA, Bales NJ, Myers SA, et al. The hypothalamic-pituitary-adrenal axis: development, programming actions of hormones, and maternal-fetal interactions. Front Behav Neurosci 2021;14:p.601939.

[10] Gao S, Wang X, Meng LB, et al. Recent progress of chronic stress in the development of atherosclerosis. Oxid Med Cell Longev 2022;2022: 4121173.

[11] Garland EL, Hanley AW, Baker AK, et al. Biobehavioral mechanisms of mindfulness as a treatment for chronic stress: an RDoC perspective. Chronic Stress (Thousand Oaks). 2017;2470547017711912.

[12] Camell CD, Sander J, Spadaro O, et al. Inflammasome-driven catecho-lamine catabolism in macrophages blunts lipolysis during ageing. Nature 2017;550:119–23.

[13] Zhang T, Chen Y, Liu H, et al. Chronic unpredictable stress accelerates atherosclerosis through promoting inflammation in apolipoprotein E knockout mice. Thromb Res 2010;126:386–92.

[14] Tang YL, Jiang JH, Wang S, et al. TLR4/NF-κB signaling contributes to chronic unpredictable mild stress-induced atherosclerosis in APOE-/-mice. PLoS One 2015;10:e0123685.

[15] Neves VJ, Moura MJCS, Tamascia ML, et al. Proatherosclerotic effects of chronic stress in male rats: altered phenylephrine sensitivity and nitric oxide synthase activity of aorta and circulating lipids. Stress 2009;12:320–27.

[16] Steptoe A, Kivimäki M. Stress and cardiovascular disease: an update on current knowledge. Annu Rev Public Health 2013;34:337–54.

[17] Esler M. Mental stress and human cardiovascular disease. Neurosci Biobehav Rev 2017;74:269–76.

[18] Kivimäki M, Jokela M, Nyberg ST, et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603,838 individuals. Lancet 2015;386:1739–46.

[19] Bergmann N, Gyntelberg F, Faber J. The appraisal of chronic stress and the development of the metabolic syndrome: a systematic review of prospective cohort studies. Endocr Connect 2014;3:R55–80.

[20] Spruill TM. Chronic psychosocial stress and hypertension. Curr Hypertens Rep 2010;12:10–16.

[21] Liu MY, Li N, Li WA, et al. Association between psychosocial stress and hypertension: a systematic review and meta-analysis. Neurol Res 2017;39:573–80.

[22] Pyun JH, Ahn BY, Vuong TA, et al. Inducible Prmt1 ablation in adult vascular smooth muscle leads to contractile dysfunction and aortic dissection. Exp Mol Med 2021;53:1569–79.

[23] Kim YS, Joo SP, Song DJ, et al. Correlation between high hair cortisol level and intracranial aneurysm rupture. Medicine (Baltimore) 2021;100: E26193.

[24] Goyal A, Maheshwari S, Abbasi HQ, et al. Development of acute kidney injury following repair of Stanford type A aortic dissection is associated with increased mortality and complications: a systematic review, meta-analysis, and meta-regression analysis. Cardiovasc Endocrinol Metab 2024;13:e00314.

[25] Ahmed R, Behary Paray N, Sawatari H, et al. Characteristics and outcomes of hospitalized patients with Isolated and systemic cardiac sarcoidosis: analysis of the nationwide readmissions database 2016-2021. Int J Cardiol Heart Vasc 2025;57:101636.

[26] Ortega-Montiel J, Posadas-Romero C, Ocampo-Arcos W, et al. Self-perceived stress is associated with adiposity and atherosclerosis. the GEA study. BMC Public Health 2015;15:1–6.

[27] Li L, Jönsson-Rylander AC, Abe K, et al. Chronic stress induces rapid occlusion of angioplasty-injured rat carotid artery by activating neuro-peptide Y and its Y1 receptors. Arterioscler Thromb Vasc Biol 2005;25: 2075–80.

[28] Rosengren A, Hawken S, Ôunpuu S, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. Lancet 2004;364:953–62.

[29] Dantzer R, O'Connor JC, Freund GG, et al. From inflammation to sickness and depression: when the immune system subjugates the brain. Nat Rev Neurosci 2008;9:46–56.

[30] Miller AH, Raison CL. The role of inflammation in depression: from evolutionary imperative to modern treatment target. Nat Rev Immunol 2016;16:22–34.

[31] Kappelmann N, Lewis G, Dantzer R, et al. Antidepressant activity of anti-cytokine treatment: a systematic review and meta-analysis of clinical trials of chronic inflammatory conditions. Mol Psychiatry 2018;23: 335–43.

[32] Raison CL, Rutherford RE, Woolwine BJ, et al. A randomized con-trolled trial of the tumor necrosis factor antagonist infliximab for treatment-resistant depression: the role of baseline inflammatory biomarkers. JAMA Psychiatry 2013;70:31–41.

[33] Hansson GK. Inflammation, atherosclerosis, and coronary artery disease. N Engl J Med 2005;352:1685–95.

[34] Ruparelia N, Choudhury R. Inflammation and atherosclerosis: what is on the horizon? Heart 2020;106:80–85.

[35] Libby P. Inflammation during the life cycle of the atherosclerotic plaque. Cardiovasc Res 2021;117:2525–36.

[36] Ministrini S, Carbone F, Montecucco F. Updating concepts on athero-sclerotic inflammation: from pathophysiology to treatment. Eur J Clin Invest 2021;51:e13467.

[37] Ridker PM, Koenig W, Kastelein JJ, et al. Has the time finally come to measure hsCRP universally in primary and secondary cardiovascular prevention? Eur Heart J 2018;39:4109–11.

[38] Ridker PM. A test in context: high-sensitivity C-reactive protein. J Am Coll Cardiol 2016;67:712–23.

[39] Rogacev KS, Cremers B, Zawada AM, et al. CD14++CD16+ mono-cytes independently predict cardiovascular events: a cohort study of 951 patients referred for elective coronary angiography. J Am Coll Cardiol 2012;60:1512–20.

[40] Goyal A, Jain H, Usman M, et al. A comprehensive exploration of novel biomarkers for the early diagnosis of aortic dissection. Hell J Cardiol 2024.

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

[41] Libby P. The changing landscape of atherosclerosis. Nature 2021; 592:524–33.

[42] Kelly PJ, Lemmens R, Tsivgoulis G. Inflammation and stroke risk: a new target for prevention. Stroke 2021;52:2697–706.

[43] Oh SE, Parikh NS. Recent advances in the impact of infection and inflammation on stroke risk and outcomes. Curr Neurol Neurosci Rep 2022;22:161–70.

[44] Hosaka K, Hoh BL. Inflammation and cerebral aneurysms. Transl Stroke Res 2014;5:190–98.

[45] Cowan LT, Alonso A, Pankow JS, et al. Hospitalized infection as a trigger for acute ischemic stroke: the atherosclerosis risk in communities study. Stroke 2016;47:1612–17.

[46] Jebari-Benslaiman S, Galicia-García U, Larrea-Sebal A, et al. Pathophysiology of atherosclerosis. Int J Mol Sci 2022;23:3346.

[47] Liu M, Liu J, Zhang L, et al. An evidence of brain-heart disorder: mental stress-induced myocardial ischemia regulated by inflammatory cytokines. Neurol Res 2020;42:670–75.

[48] Nicola JP, Bosch JA, Jet JCS, Veldhuijzen Van Zanten J. Inflammation and vascular responses to acute mental stress: implications for the triggering of myocardial infarction. Curr Pharm Des 2012;18:1494–501.

[49] Hammadah M, Sullivan S, Pearce B, et al. Inflammatory response to mental stress and mental stress induced myocardial ischemia. Brain Behav Immun 2018;68:90–97.

[50] Kalogeropoulos A, Georgiopoulou V, Psaty BM, et al. Inflammatory markers and incident heart failure risk in older adults: the Health ABC (Health, Aging, and Body Composition) study. J Am Coll Cardiol 2010;55:2129–37.

[51] Kang DO, Eo JS, Park EJ, et al. Stress-associated neurobiological activity is linked with acute plaque instability via enhanced macrophage activity: a prospective serial 18F-FDG-PET/CT imaging assessment. Eur Heart J 2021;42:1883–95.

[52] Saeed H, Abdullah MBBS, Naeem I, et al. Demographic trends and disparities in mortality related to coexisting heart failure and diabetes mellitus among older adults in the United States between 1999 and 2020: a retrospective population-based cohort study from the CDC WONDER database. Int J Cardiol Cardiovasc Risk Prev 2024;23:200326.

[53] Sumner JA, Cleveland S, Chen T, et al. Psychological and biological mechanisms linking trauma with cardiovascular disease risk. Transl Psychiatry 2023;13:25.

[54] Rutledge T, Reis VA, Linke SE, et al. Depression in heart failure a meta-analytic review of prevalence, intervention effects, and associations with clinical outcomes. J Am Coll Cardiol 2006;48:1527–37.

[55] Lespérance F, Frasure-Smith N. Depression in patients with cardiac disease: a practical review. J Psychosom Res 2000;48:379–91.

[56] Havranek EP, Ware MG, Lowes BD. Prevalence of depression in congestive heart failure. Am J Cardiol 1999;84:348–50.

[57] Guck TP, Elsasser GN, Kavan MG, et al. Depression and congestive heart failure. Congest Heart Fail 2003;9:163–69.

[58] Rudisch B, Nemeroff CB. Epidemiology of comorbid coronary artery disease and depression. Biol Psychiatry 2003;54:227–40.

[59] Whooley MA. Depression and cardiovascular disease: healing the broken-hearted. JAMA 2006;295:2874–81.

[60] Hare DL, Toukhsati SR, Johansson P, et al. Depression and cardiovascular disease: a clinical review. Eur Heart J 2014;35:1365–72.

[61] Jiang W, Alexander J, Christopher E, et al. Relationship of depression to increased risk of mortality and rehospitalization in patients with congestive heart failure. Arch Intern Med 2001;161:1849–56.

[62] Thombs BD, Bass EB, Ford DE, et al. Prevalence of depression in survivors of acute myocardial infarction. J Gen Intern Med 2006;21:30–38.

[63] Huffman JC, Celano CM, Beach SR, et al. Depression and cardiac disease: epidemiology, mechanisms, and diagnosis. Cardiovasc Psychiatry Neurol 2013;2013:695925.

[64] Bahall M, Legall G, Khan K. Quality of life among patients with cardiac disease: the impact of comorbid depression. Health Qual Life Outcomes 2020;18:1–10.

[65] Sharma Dhital P, Sharma K, Poudel P, et al. Anxiety and depression among patients with coronary artery disease attending at a cardiac center, Kathmandu, Nepal. Nurs Res Pract 2018;2018:1–6.

[66] Sumlin LL, Garcia TJ, Brown SA, et al. Depression and adherence to lifestyle changes in type 2 diabetes: a systematic review. Diabetes Educ 2014;40:731–44.

[67] Gezginci E, Kosucu SN, Goktas S, et al. Relationship between depression and healthy lifestyle behaviors of patients with history of transplant. Transplant Proc 2019;51:2367–72.

[68] Al-Zaru IM, Alhalaiqa F, Dalky HF, et al. Depression in nonhospitalized Jordanian patients with coronary artery disease. J Nurs Res 2020;28:e66.

[69] Whooley MA, De Jonge P, Vittinghoff E, et al. Depressive symptoms, health behaviors, and risk of cardiovascular events in patients with coronary heart disease. JAMA 2008;300:2379–88.

[70] Serrano CV, Tiemi Setani K, Sakamoto E, et al. Association between depression and development of coronary artery disease: pathophysiologic and diagnostic implications. Vasc Health Risk Manag 2011;7:159–64.

[71] Murphy BM, Le Grande MR, Navaratnam HS, et al. Are poor health behaviours in anxious and depressed cardiac patients explained by sociodemographic factors? Eur J Prev Cardiol 2013;20:995–1003.

[72] Hoen PW, Denollet J, De Jonge P, et al. Positive affect and survival in patients with stable coronary heart disease: findings from the heart and soul study. J Clin Psychiatry 2013;74:716–22.

[73] Sin NL, Moskowitz JT, Whooley MA. Positive affect and health behaviors across 5 years in patients with coronary heart disease: the heart and soul study. Psychosom Med 2015;77:1058–66.

[74] Penninx BW, Pine DS, Holmes EA, et al. Anxiety disorders. Lancet 2021;397:914–27.

[75] Jia Z, Du X, Du J, et al. Prevalence and factors associated with depressive and anxiety symptoms in a Chinese population with and without cardiovascular diseases. J Affect Disord 2021;286:241–47.

[76] Emdin CA, Odutayo A, Wong CX, et al. Meta-analysis of anxiety as a risk factor for cardiovascular disease. Am J Cardiol 2016;118:511–19.

[77] Wu SC, Fang CW, Chen WTL, et al. Acid-reducing vagotomy is associated with reduced risk of subsequent ischemic heart disease in complicated peptic ulcer: an Asian population study. Medicine (Baltimore) 2016;95:e5651.

[78] Walli-Attaei M, Rosengren A, Rangarajan S, et al. Metabolic, behavioural, and psychosocial risk factors and cardiovascular disease in women compared with men in 21 high-income, middle-income, and low-income countries: an analysis of the PURE study. Lancet 2022;400:811–21.

[79] Howren MB, Lamkin DM, Suls J. Associations of depression with C-reactive protein, IL-1, and IL-6: a meta-analysis. Psychosom Med 2009;71:171–86.

[80] Li YC, Chou YC, Chen HC, et al. Interleukin-6 and interleukin-17 are related to depression in patients with rheumatoid arthritis. Int J Rheum Dis 2019;22:980–85.

[81] Celano CM, Daunis DJ, Lokko HN, et al. Anxiety disorders and cardiovascular disease. Curr Psychiatry Rep 2016;18:1–11.

[82] Alvarenga ME, Byrne D. Anxiety and cardiovascular disease: epidemiology and proposed mechanisms. Handbook of Psychocardiol. 2016;247–63.

[83] Chen J, Yan F, Kuttappan VA, et al. Effects of bis-chelated copper in growth performance and gut health in broiler chickens subject to coccidiosis vaccination or coccidia challenge. Front Physiol 2023;13:991318.

[84] Mommersteeg PMC, Schoemaker RG, Eisel ULM, et al. Nitric oxide dysregulation in patients with heart failure: the association of depressive symptoms with L-arginine, asymmetric dimethylarginine, symmetric dimethylarginine, and isoprostane. Psychosom Med 2015;77:292–302.

[85] Hinterdobler J, Schott SS, Jin H, et al. Acute mental stress drives vascular inflammation and promotes plaque destabilization in mouse atherosclerosis. Eur Heart J 2021;42:4077–88.

[86] Adibfar A, Saleem M, Lanctot KL, et al. Potential biomarkers for depression associated with coronary artery disease: a critical review. Curr Mol Med 2016;16:137–64.

[87] Wilke MR, Broschmann D, Sandek A, et al. Longitudinal association between N-terminal B-type natriuretic peptide, anxiety and social support in patients with HFpEF: results from the multicentre randomized controlled Aldo-DHF trial. BMC Cardiovasc Disord 2023;23:184.

[88] De Hert M, Correll CU, Bobes J, et al. Physical illness in patients with severe mental disorders. I. prevalence, impact of medications and disparities in health care. World Psychiatry 2011;10:52–77.

[89] Correll CU, Detraux J, De Lepeleire J, et al. Effects of antipsychotics, antidepressants and mood stabilizers on risk for physical diseases in people with schizophrenia, depression and bipolar disorder. World Psychiatry 2015;14:119–36.

[90] de Hert M, Detraux J. Reversing the downward spiral for people with severe mental illness through educational innovations. World Psychiatry 2017;16:41–42.

[91] Correll CU, Solmi M, Veronese N, et al. Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls. World Psychiatry 2017;16:163–80.

[92] Whooley MA, Wong JM. Depression and cardiovascular disorders. Annu Rev Clin Psychol 2013;9:327–54.

[93] Seligman F, Nemeroff CB. The interface of depression and cardiovascular disease: therapeutic implications. Ann N Y Acad Sci 2015;1345:25–35.

[94] Williams MS. Platelets and depression in cardiovascular disease: a brief review of the current literature. World J Psychiatry 2012;2:114.

[95] Ren Y, Ren Y, Yang H, et al. Performance of screening tools in detecting major depressive disorder among patients with coronary heart disease: a systematic review. Med Sci Monit 2015;21:646–53.

[96] Doyle F, McGee H, Conroy R, et al. Systematic review and individual patient data meta-analysis of sex differences in depression and prognosis in persons with myocardial infarction: a MINDMAPS study. Psychosom Med 2015;77:419–28.

[97] Gan Y, Gong Y, Tong X, et al. Depression and the risk of coronary heart disease: a meta-analysis of prospective cohort studies. BMC Psychiatry 2014;14:1–11.

[98] Wu Q, Kling JM. Depression and the risk of myocardial infarction and coronary death: a meta-analysis of prospective cohort studies. Medicine (Baltimore) 2016;95:e2815.

[99] Roest AM, Martens EJ, de Jonge P, et al. Anxiety and risk of incident coronary heart disease: a meta-analysis. J Am Coll Cardiol 2010;56:38–46.

[100] Vilchinsky N, Ginzburg K, Fait K, et al. Cardiac-disease-induced PTSD (CDI-PTSD): a systematic review. Clin Psychol Rev 2017;55:92–106.

[101] Gale CR, Batty GD, Osborn DPJ, et al. Mental disorders across the adult life course and future coronary heart disease: evidence for general susceptibility. Circulation 2014;129:186–93.

[102] Shen Q, Mikkelsen DH, Luitva LB, et al. Psychiatric disorders and subsequent risk of cardiovascular disease: a longitudinal matched cohort study across three countries. EClinicalMedicine 2023;61.

[103] Wu CK, Huang YT, Lee JK, et al. Anti-anxiety drugs use and cardiovascular outcomes in patients with myocardial infarction: a national wide assessment. Atherosclerosis 2014;235:496–502.

[104] Sato Y, Yoshihisa A, Hotsuki Y, et al. Associations of benzodiazepine with adverse prognosis in heart failure patients with insomnia. J Am Heart Assoc 2020;9:e013982.

[105] Carmin CN, Ownby RL, Fontanella C, et al. Impact of mental health treatment on outcomes in patients with heart failure and ischemic heart disease. J Am Heart Assoc 2024;13:e031117.

[106] Zabel KM, Quazi MA, Leyba K, et al. Cardiac arrest mortality and disposition patterns in United States emergency departments. J Clin Med 2024;13:5585.

[107] Jiang W, Krishnan R, Kuchibhatla M, et al. Characteristics of depression remission and its relation with cardiovascular outcome among patients with chronic heart failure (From the SADHART-CHF Study). Am J Cardiol 2011;107:545.

[108] O'Connor CM, Jiang W, Kuchibhatla M, et al. Safety and efficacy of sertraline for depression in patients with heart failure: results of the SADHART-CHF (Sertraline Against Depression and Heart Disease in Chronic Heart Failure) trial. J Am Coll Cardiol 2010;56:692–99.

[109] Huffman JC, Stern TA. Neuropsychiatric consequences of cardiovascular medications. Dialogues Clin Neurosci 2007;9:29–45.

[110] Shah K, Parekh N, Clopton P, et al. Improved survival in patients with diastolic heart failure discharged on beta-blocker and ace inhibitors. J Am Coll Cardiol 2013;61:E634.

[111] Bangalore S, Messerli FH, Kostis JB, et al. Cardiovascular protection using beta-blockers: a critical review of the evidence. J Am Coll Cardiol 2007;50:563–72.

[112] Cojocariu SA, Maștaleru A, Sascău RA, et al. Neuropsychiatric consequences of lipophilic beta-blockers. Medicina (B Aires) 2021;57:1–13. (Kaunas)

[113] Martino E, Bartalena L, Bogazzi F, et al. The effects of amiodarone on the thyroid. Endocr Rev 2001;22:240–54.

[114] Jain H, Ahmed M, Tariq MD, et al. Right ventricular strain as a predictor of trastuzumab-induced chemotherapy-related cardiac dysfunction: a meta-analysis. Curr Probl Cardiol 2025;50:102919.

[115] Shah M, Shrestha K, Tseng CW, et al. Statin-associated muscle symptoms: a comprehensive exploration of epidemiology, pathophysiology, diagnosis, and clinical management strategies. Int J Rheum Dis 2024;27:e15337.

[116] Thompson TS, Barksdale DJ, Sears SF, et al. The effect of anxiety and depression on symptoms attributed to atrial fibrillation. Pacing Clin Electrophysiol 2014;37:439–46.

[117] Young-Xu Y, Chan KA, Liao JK, et al. Long-term statin use and psychological well-being. J Am Coll Cardiol 2003;42:690–97.

[118] Hoogwegt MT, Kupper N, Damj T, et al. Beta-blocker therapy is not associated with symptoms of depression and anxiety in patients receiving an implantable cardioverter-defibrillator. Europace 2012;14:74–80.

[119] Jain H, Tariq MD, Khan AM, et al. Efficacy of leadless ultrasound-based left ventricular endocardial pacing for cardiac resynchronization therapy: a meta-analysis. Curr Cardiol Rev March 26, 2025. doi:10.1097/CRD.0000000000000897

[120] Rath S, Abdelraouf MR, Hassan W, et al. The impact of intraosseous vs intravenous vascular access during resuscitation in out-of-hospital cardiac arrest: a comprehensive systematic review and meta-analysis. Heart Lung 2025;72:20–31.

[121] Zhang L, Bao Y, Tao S, et al. The association between cardiovascular drugs and depression/anxiety in patients with cardiovascular disease: a meta-analysis. Pharmacol Res 2022;175:106024.

[122] Rotvig C, Christensen AV, Juel K, et al. The association between cardiac drug therapy and anxiety among cardiac patients: results from the national DenHeart survey. BMC Cardiovasc Disord 2022;22:280.

[123] The interplay between mental health and physical illness: a guide for healthcare practitioners in functional medicine [internet]. Cited [2024 Nov 10]. Available from: https://www.rupahealth.com/post/the-interplay-between-mental-health-and-physical-illness-a-guide-for-healthcare-practitioners-in-functional-medicine

[124] Ee C, Lake J, Firth J, et al. An integrative collaborative care model for people with mental illness and physical comorbidities. Int J Ment Health Syst 2020;14:1–16.

[125] Daumit GL, Dalcin AT, Dickerson FB, et al. Effect of a comprehensive cardiovascular risk reduction intervention in persons with serious mental illness: a randomized clinical trial. JAMA Netw Open 2020;3:e207247.

[126] Milos Nymberg V, Nymberg P, Pikkemaat M, et al. Lifestyle and cardiovascular risk factors in a Swedish primary care population with self-reported psychiatric symptoms. Prev Med Rep 2023;37:102547.

[127] Atlantis E, Fahey P, Foster J. Collaborative care for comorbid depression and diabetes: a systematic review and meta-analysis. BMJ Open 2014;4:e004706.

[128] Teachout A, Kaiser SM, Wilkniss SM, et al. Paxton House: integrating mental health and diabetes care for people with serious mental illnesses in a residential setting. Psychiatr Rehabil J 2011;34:324–27.

[129] Tsan JY, Zeber JE, Stock EM, et al. Primary care-mental health integration and treatment retention among Iraq and Afghanistan war veterans. Psychol Serv 2012;9:336–48.

[130] Liang D, Mays VM, Hwang WC. Integrated mental health services in China: challenges and planning for the future. Health Policy Plan 2018;33:107–22.

[131] Druss BG, Von Esenwein SA, Glick GE, et al. Randomized trial of an integrated behavioral health home: the health outcomes management and evaluation (HOME) study. Am J Psychiatry 2017;174:246–55.

[132] Druss BG, Von Esenwein SA, Compton MT, et al. A randomized trial of medical care management for community mental health settings: the Primary Care Access, Referral, and Evaluation (PCARE) study. Am J Psychiatry 2010;167:151–59.

[133] De Marchis EH, Doekhie K, Willard-Grace R, et al. The impact of the patient-centered medical home on health care disparities: exploring stakeholder perspectives on current standards and future directions. Popul Health Manag 2019;22:99–107.

[134] Coleman KJ, Magnan S, Neely C, et al. The COMPASS initiative: description of a nationwide collaborative approach to the care of patients with depression and diabetes and/or cardiovascular disease. Gen Hosp Psychiatry 2017;44:69–76.

[135] David G, Gunnarsson C, Saynisch PA, et al. Do patient-centered medical homes reduce emergency department visits? Health Serv Res 2015;50:418–39.

[136] Sum G, Sim SYH, Chay J, et al. An integrated patient-centred medical home (PCMH) care model reduces prospective healthcare utilisation

Singh et al. Annals of Medicine & Surgery (2025)

Annals of Medicine & Surgery

for community-dwelling older adults with complex needs: a matched observational study in Singapore. Int J Environ Res Public Health 2023;20:6848.

[137] Mehraeen E, SeyedAlinaghi SA, Heydari M, *et al.* Telemedicine technologies and applications in the era of COVID-19 pandemic: a systematic review. Health Informatics J 2023;29:14604582231167431.

[138] Anthony Jnr B. Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. J Med Syst 2020;44:1–9.

[139] Jackson TN, Sreedhara M, Bostic M, *et al.* Telehealth use to address cardiovascular disease and hypertension in the United States: a systematic review and meta-analysis, 2011-2021. Telemed Rep 2023;4:67–86.

[140] Palmer CS, Brown Levey SM, Kostiuk M, *et al.* Virtual care for behavioral health conditions. Prim Care 2022;49:641–57.

[141] Reed RN, Messler EC, Coombs TE, *et al.* Social media use and the acceptability of telepsychological services in rural populations. J Rural Mental Health 2014;38:2–8.

[142] Philippe TJ, Sikder N, Jackson A, *et al.* Digital health interventions for delivery of mental health care: systematic and comprehensive meta-review. JMIR Ment Health 2022;9:e35159.

[143] Hung CS, Yu JY, Lin YH, *et al.* Mortality benefit of a fourth-generation synchronous telehealth program for the management of chronic cardiovascular disease: a longitudinal study. J Med Internet Res 2016;18:e102.

[144] Jin K, Khonsari S, Gallagher R, *et al.* Telehealth interventions for the secondary prevention of coronary heart disease: a systematic review and meta-analysis. Eur J Cardiovasc Nurs 2019;18:260–71.

[145] Kern LM, Safford MM, Slavin MJ, *et al.* Patients' and providers' views on causes and consequences of healthcare fragmentation in the ambulatory setting: a qualitative study. J Gen Intern Med 2019;34: 899–907.

[146] Lyngsø AM, Godtfredsen NS, Frølich A. Interorganisational integration: healthcare professionals' perspectives on barriers and facilitators within the Danish healthcare system. Int J Integr Care 2016;16:4.

[147] Gilles I, Filliettaz SS, Berchtold P, *et al.* Financial barriers decrease benefits of interprofessional collaboration within integrated care programs: results of a nationwide survey. Int J Integr Care 2020;20:10.

[148] Keeves J, Braaf SC, Ekegren CL, *et al.* Access to healthcare following serious injury: perspectives of allied health professionals in urban and regional settings. Int J Environ Res Public Health 2021;18:1–16.

[149] van den Houdt SCM, Widdershoven J, Kupper N. Patient and healthcare professionals' perceived barriers and facilitators to the implementation of psychosocial screening in cardiac practice: a Delphi study. Gen Hosp Psychiatry 2023;85:104–13.