

PHILIPS

Women's heart health

Literature review



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Executive summary

Cardiovascular disease (CVD) represents the leading cause of mortality and morbidity in women worldwide, yet women's CVD remains substantially underrecognized, underdiagnosed, undertreated and understudied compared to men's CVD.¹ This disparity stems from historical biases in medical knowledge, persistent gaps in clinical training, diagnostic tools largely based on male data, underrepresentation in research and systemic policy blind spots. The consequences are measurable and tragic: women experience delayed diagnosis, receive fewer interventions and face worse outcomes following cardiovascular events.

Addressing women's cardiovascular health requires action across multiple levels including the following:

- Redesigning diagnostic approaches to reflect CVD symptomology and presentation in women
- Expanding healthcare provider training in female-specific cardiovascular presentation and management
- Ensuring women's representation in clinical trials and research with sex-stratified data analysis
- Incorporating sex and gender perspectives into health policy and payer policies
- Ensuring that emerging technologies such as artificial intelligence (AI) are developed and validated in diverse, female-inclusive populations

Women's cardiovascular health is both an urgent clinical need and a significant opportunity for innovation, improved outcomes and economic impact. Growing awareness campaigns are starting to reach women. Innovation in digital health, AI, and the emergence of women's heart clinics offer unprecedented opportunities to democratize cardiovascular screening and enable truly personalized, accessible cardiac care for all women.

The future of women's cardiovascular health needs sustained commitment, adequate investment, and partnerships across hospitals, professional medical societies, patient organizations, academia, policy makers, and industry (including medtech, pharma, and life sciences). Together they can drive a deliberate paradigm shift away from male-centered models toward female-inclusive, female-informed care.

Women's health: current reality

Today, women remain under-represented at every stage of their healthcare journey: they experience diagnostic delays, receive fewer diagnostic tests, are less likely to be referred to specialists and continue to be structurally excluded from clinical trials.² Between 2013 and 2023, only 8.8% of National Institutes of Health (NIH)-funded research focused exclusively on women, while globally merely 1% of research and development funding is allocated to female-specific conditions beyond oncology.³ This is not an oversight, but a structural inequity embedded in healthcare systems worldwide.

Beyond the moral imperative, there is a compelling economic rationale. Keeping women healthy means more consistent participation in the workforce, fewer sick days from preventable illness and higher productivity for both men and women, with women representing half the population and half the global workforce. In the US alone, maintaining working women's health prevents employer losses of USD 65 billion annually.⁴ Improved women's health outcomes also strengthen families and enhance the future earnings and productivity of subsequent generations. At the macroeconomic level, the extent to which countries prioritize women's health directly correlates with broader economic performance and population health outcomes.⁵

Cardiovascular disease: the leading health crisis for women

CVD is the leading cause of death among women worldwide, accounting for nearly two-thirds of all female deaths in some European countries.⁶ Over a 30-year period, from 1990 to 2019, the global burden of CVD in women increased by 74%,⁷ representing a rapidly accelerating crisis. Currently, 44% of women in the US live with some form of heart disease.⁸ In contrast to breast cancer, which causes the death of 1 in 43 women, CVD accounts for 1 in every 3 female deaths.⁹

This extraordinary burden creates substantial consequences for individuals, families, healthcare systems and economies. Across Europe, approximately 256 million working days were lost in 2021 due to illness and disability associated with CVD, and 1.3 million working years were lost due to premature deaths, resulting in a total workforce impact of EUR 47 billion.⁶

For women specifically, CVD represents the single greatest threat to well-being, making it absolutely central to any comprehensive approach to women's health; therefore, understanding, diagnosing and treating women's CVD is a fundamental health priority.

The unique cardiovascular risk profile in women

Women's cardiovascular risk differs fundamentally from that for men in both scope and mechanism. While traditional CVD risk factors (hypertension, high cholesterol, diabetes, obesity, smoking and physical inactivity) affect both sexes, these risks produce greater adverse health consequences in women than in men.¹⁰ Despite robust evidence that prevention works, women encounter barriers at every stage of prevention, from primordial prevention (preventing risk factors from developing) through primary, secondary and tertiary prevention (managing established disease).

More significantly, women face CVD risk factors that do not occur in men, many intricately linked to reproductive and hormonal changes across a woman's entire lifespan such as the following:

- Pregnancy introduces unique cardiovascular risk factors not applicable in men including peripartum cardiomyopathy, pregnancy-associated spontaneous coronary artery dissection (SCAD) and preeclampsia; gestational hypertension, for example, is not just a temporary condition, but a risk factor for future CVD, as women who experience high blood pressure during pregnancy face substantially higher rates of adverse cardiovascular events in later life
- Early menopause (occurring before age 40 years) is associated with a 40% higher lifetime risk of coronary heart disease compared to women with typical menopause timing¹¹
- Polycystic ovary syndrome (PCOS) and endometriosis, both highly prevalent in women of reproductive age, carry significant long-term cardiovascular consequences that persist well beyond the reproductive years
- Some breast cancer treatments, such as anthracycline chemotherapy, have been associated with an elevated CVD risk¹²
- Women are also disproportionately affected by autoimmune diseases such as lupus erythematosus and rheumatoid arthritis, conditions that directly damage cardiac tissue and dramatically elevate CVD risk¹³; these conditions occur with higher frequency in women than in men and carry greater risk of cardiovascular morbidity and mortality

Beyond biomedical factors, women's daily lives present structural barriers to cardiovascular health. Women often carry disproportionate birth control responsibilities,¹⁴ which may involve the use of combined oral contraceptives. This poses a higher risk of cardiovascular disease for certain women.¹⁵ Women also often carry disproportionate caregiving responsibilities (for children, aging parents and sick family members) that are frequently unpaid and largely invisible in healthcare conversations. These responsibilities, combined with economic instability and other social determinants of health, limit women's capacity to prioritize preventive care, adopt and maintain healthy behaviors and engage consistently with treatment regimens.¹³ Addressing women's cardiovascular health requires acknowledging and addressing this full spectrum of risk factors: biological, social and structural.

Diagnostic gaps: why women's heart disease goes unrecognized

The challenge of symptom recognition

CVD in women is frequently misdiagnosed or diagnosed substantially later than in men, with delays of 7-10 years not uncommon.¹³ This diagnostic failure begins with symptoms. Women and men experience and report CVD symptoms differently. While men typically present with classical chest pain, women frequently describe fatigue, nausea, dizziness, shortness of breath or back pain.⁸ Healthcare professionals (HCPs), trained on predominantly male clinical presentations, often miss these symptoms or attribute them to anxiety, stress or other noncardiac causes. These symptoms are entirely typical for women; the issue is that clinical training and diagnostic protocols were developed using male-predominant data.

Anatomical differences requiring different diagnostic approaches

Women's hearts are structurally and functionally different from men's hearts in ways that fundamentally affect disease presentation and diagnosis. Women's hearts are approximately 10-15% smaller than men's hearts.¹⁶ Beyond size, women have distinct coronary vasculature, with different microvascular function, endothelial properties and unique structural geometry compared to men.

These differences are not minor variations but substantive physiological distinctions with significant clinical implications.

Critically, men and women develop different patterns of coronary artery disease. Men typically develop large artery blockages (obstructive plaque in major coronary vessels) that are relatively easy to visualize on angiography. Women, by contrast, more frequently develop diffuse, non-obstructive plaque patterns affecting the small blood vessels of the heart.

The following cardiovascular conditions and clinical syndromes are particularly prevalent in women:

1. Cardiovascular conditions

- Coronary microvascular dysfunction (CMD)
- Spontaneous coronary artery dissection (SCAD)
- Heart failure with preserved ejection fraction (HFpEF)
- Takotsubo cardiomyopathy ('broken heart syndrome')

2. Clinical syndromes of non-obstructive coronary artery disease

- Ischemia with non-obstructed coronary arteries (INOCA)
- Myocardial injury with non-obstructive coronary arteries (MINOCA)¹⁷

These conditions are genuine and dangerous, yet they are less easily detected using common diagnostic tools designed for obstructive disease patterns. Here is more information on each of these conditions.

1. Cardiovascular conditions

- CMD

CMD is a disease of the small coronary vessels rather than large arteries and is characterized by chest pain and ischemia with normal angiograms. CMD occurs disproportionately in women, and leads to chronic angina and reduced quality of life, but is often missed because standard tests look for large artery blockages.

- SCAD

SCAD is a tear in a coronary artery wall that reduces blood flow to the heart. It is important for women because it occurs overwhelmingly in this sex (80-90%), usually in young or middle-aged women during or after pregnancy. SCAD is a major cause of heart attacks in women age under 50 years; however, SCAD is often under-recognized because coronary arteries may appear normal on standard angiography and symptoms resemble typical heart attacks.

- HFpEF

HFpEF is a form of heart failure in which the heart pumps normally but relaxes poorly. It is the most common type of heart failure in women; women are more likely to develop HFpEF due to hypertension, obesity and metabolic factors. HFpEF is difficult to diagnose and treat, with limited

effective therapies.

- Takotsubo cardiomyopathy ('broken heart syndrome')

Takotsubo cardiomyopathy is a temporary heart muscle dysfunction triggered by severe emotional or physical stress and occurs mostly (90%) in postmenopausal women. The symptoms of Takotsubo cardiomyopathy mimic heart attack (chest pain, electrocardiogram [ECG] changes).

Clinical syndromes of non-obstructive coronary artery disease

- INOCA

INOCA is a condition in which the heart muscle receives insufficient oxygen-rich blood despite the absence of significant blockages in the major coronary arteries. It is most commonly driven by coronary microvascular dysfunction, coronary vasospasm or both. Predominantly affecting women, INOCA is frequently under-recognized because standard diagnostic tests focus on detecting obstructive disease. Consequently, many patients suffer from ongoing symptoms, reduced quality of life, and an elevated risk of adverse cardiovascular events, despite being reassured that their coronary arteries are 'normal'.

- MINOCA

MINOCA is a working diagnosis rather than a final diagnosis. It applies when a patient has acute myocardial injury without an obstructive major coronary artery lesion. Symptoms, ECG changes or cardiac-troponin changes may suggest myocardial infarction, but further investigation is required to identify the underlying cause. Common mechanisms include coronary vasospasm, coronary microvascular dysfunction, SCAD and coronary embolism.¹⁷

Diagnostic tools not optimized for women

The diagnostic tools and treatment protocols currently standard in clinical practice have been developed, validated and optimized using predominantly male study populations. The interpretation accuracy of ECGs is systematically lower in women than in men. Invasive coronary angiography (considered the gold standard for diagnosing coronary disease) is technically more challenging to perform in women, particularly given their smaller coronary vessels and different disease patterns. Coronary flow reserve measurements are often higher in women than men, while fractional flow reserve values tend to be lower, reflecting their distinct cardiac physiology.¹⁶ Some imaging modalities have reduced reliability in women due to breast tissue interference with imaging quality.¹⁶ Collectively, these systematic differences in diagnostic accuracy mean that women are substantially under-diagnosed for CVD.¹⁶

Biomarker differences requiring sex-specific thresholds

Biomarkers used to diagnose CVD and monitor disease progression differ between men and women. For example, cardiac troponin I, a marker of heart muscle injury, naturally occurs at different levels in healthy men versus healthy women.¹⁸ Using male-derived thresholds to interpret women's troponin levels results in missed diagnoses. Sex-specific cut-off values for biomarkers are essential for appropriate diagnosis but remain underutilized in current practice.

Knowledge gaps in healthcare provider training

Diagnostic failures are partly explained by gaps in medical education. Medical schools provide limited sex-specific training in CVD, and very few certified training programs focus specifically on women's cardiovascular health. Survey data reveals that only 22% of primary care physicians and 42% of cardiologists in the US report feeling extremely well prepared to assess CVD risk in women.¹⁹ These knowledge gaps translate directly into missed diagnoses and delayed care.

Some healthcare systems have begun addressing this deficit; for example, the Canadian Women's Heart Health Alliance developed a specialized Women's Cardiovascular Health Education Course that has been integrated into medical education curricula. Such initiatives demonstrate that targeted education can improve clinical recognition of CVD in women. Fundamentally, CVD in women will continue to be under-diagnosed until diagnostic approaches are redesigned to reflect women's actual cardiac anatomy and physiology, until diagnostic tools are validated in women, and until healthcare providers receive comprehensive training in sex-specific cardiovascular presentation and management.

Treatment disparities along the care pathway

Even after CVD is diagnosed, women face significant barriers to appropriate treatment. When acute cardiovascular events occur, women experience longer emergency response times than men. After diagnosis, women are less likely to be referred to cardiology specialists for advanced care compared to men with similar disease severity.¹³ Women have systematically lower access to cardiac rehabilitation programs following acute events or procedures. For example, women undergoing coronary artery bypass grafting experience higher rates of death, stroke and hospital readmission than men⁴ and women are 50% more likely to die within 1 year following a heart attack.²⁰ These data highlight the cumulative implications of delayed diagnosis, undertreatment and inadequate post-event management in women.

Research and evidence gaps: a male-centric knowledge base

Women remain significantly underrepresented in clinical trials and cardiovascular research studies: a gap with profound implications. The evidence that healthcare providers use to guide treatment decisions (including optimal dosing, efficacy and safety profiles of medications) is overwhelmingly based on predominantly male study populations and, therefore, less reliable in, and generalizable to, women.²¹ This evidence gap means that care protocols and treatment guidelines are anchored to male-centered cardiovascular physiology rather than reflecting the sex-specific factors that drive CVD in women. Future research must prioritize sex-balanced recruitment into clinical studies and systematically examine sex-based differences in study data. Only when data are stratified and reported by sex will differences in women's responses to treatments become visible, enabling the development of CVD care truly tailored to women's physiology and needs.

Policy and leadership: a systemic blind spot

Because women are understudied in clinical research and underrepresented in medical literature, they are largely overlooked in health policy development. The epidemiological and clinical datasets currently used by insurers, payers and healthcare systems systematically undercount and undervalue the health burden experienced by women. This leads to underestimation of disease severity in women and, consequently, unequal access to healthcare services and technologies. Representation of women in senior leadership roles in cardiology remains limited, despite recent efforts such as the

formation of the European Society of Cardiology's Gender Task Force to drive gender equity. This leadership gap perpetuates the cycle of under-recognition and under-prioritization of women's cardiovascular health concerns.

Current state of prevention and innovation in women's cardiovascular care

Awareness campaigns focused on women's cardiovascular health currently exist in multiple forms, including the American Heart Association's Go Red for Women initiative, dedicated collections in medical journals, and dedicated websites such as Heart Health for Women. These efforts aim to empower women to understand their unique cardiovascular symptoms, risk factors and prevention strategies. Beyond awareness, there is growing recognition that innovation in women's health represents a significant opportunity for companies and health systems to advance health outcomes while simultaneously building consumer loyalty and business success.

Digital health technologies and AI have substantial potential to transform women's access to, and receipt of, cardiovascular care. AI-enabled tools can standardize and accelerate critical diagnostic procedures such as echocardiography and angiography. AI-powered wearable devices and monitoring systems can detect early warning signs of hypertension, cardiac arrhythmias, low ejection fraction and valve disease in real-time.^{22,23} By embedding these tools into smartwatches, mobile phones and home-based devices, cardiovascular screening, imaging, echocardiography monitoring²⁴ and remote follow-up become accessible far beyond traditional hospital and specialty clinic settings, bringing cardiac care into women's daily lives and enabling proactive, personalized health management.

However, this technological advancement carries a critical risk. Current AI algorithms are trained on datasets that significantly underrepresent female patients. Research has demonstrated that AI models (such as those estimating ejection fraction from cardiac imaging) show sex-based performance disparities, with reduced diagnostic accuracy in women compared to men. To prevent AI from perpetuating and amplifying existing sex-based biases in cardiovascular care, datasets used to train AI algorithms must be deliberately diverse and representative, must incorporate evidence specifically generated in women, and must account for the anatomical differences between men's hearts and women's hearts.

Women's heart clinics (WHCs) represent a specialized care model designed specifically to address women's cardiovascular health needs. These centers provide comprehensive cardiovascular care with focused expertise in female-specific CVD risks and management of cardio-obstetrics (pregnancy-related cardiac issues), cardio-oncology (cancer therapy-related cardiac injury) and cardio-neurology.²⁵ WHCs combine clinical care, research, education, and advocacy to address the unique needs of women with CVD. While comprehensive data on WHC impact on cardiovascular outcomes is still emerging due to the complexity of CVD and heterogeneity of populations served, published studies document meaningful benefits. Women attending WHCs report increased awareness of their personal cardiovascular risk. WHCs have demonstrated success in improving blood pressure control among women with hypertension, a critical outcome given the particular cardiovascular burden hypertension carries for women. For women with high-risk pregnancies complicated by hypertension, gestational diabetes or other adverse pregnancy outcomes, WHCs have achieved significant reductions in multiple cardiovascular risk factors, preventing future disease.

WHCs also play an important role in accurately diagnosing conditions specific to women, such as MINOCA and INOCA, conditions that might otherwise be dismissed or misdiagnosed in conventional cardiology settings.

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