VIEW POINT

HEART OF TECHNOLOGY:
'AI'NNOVATION IN CARDIAC HEALTH

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Introduction

The heart is one of the most important and delicate organs in the human body, working constantly to pump blood and keep us alive. However, it is not invincible. One of the most serious and common threats to the heart is a myocardial infarction (MI), also known as a heart attack.

Cardiovascular diseases, encompassing coronary heart disease, heart failure, stroke, and hypertension, stand as the leading cause of death globally. In 2020 alone, nearly 702,880 lives were claimed by heart disease in the United States, equating to approximately 1 in every 5 deaths.[1]

It's both surprising and concerning that high mortality rates from MI persist, despite advancements in timely medical interventions that significantly increase survival rates.[2] This raises the question: where are we falling short?

This paper endeavors to explore the challenges, key drivers, and technological innovations needed for the effective management of heart diseases.

Key Drivers

The critical consequence of various cardiovascular diseases (CVDs), often proving fatal in most cases is MI. It occurs when a coronary artery becomes blocked, typically due to the buildup of plaque, leading to the death of heart muscle tissue. It serves as a pivotal indicator of the severity and impact of cardiovascular health challenges globally. Understanding the below key drivers and their associated statistics helps comprehend how the complex interplay of biological, behavioral, and environmental factors contributes to the need of cardiac health management.

High Blood Pressure (Hypertension): High blood pressure places undue stress on the heart and blood vessels. Globally, 1.28 billion adults aged 30–79 years have hypertension and is a significant risk factor for MI.[3] Chronic hypertension damages the arterial walls, making them more susceptible to plaque buildup. Moreover, untreated high blood pressure can potentially amplify the risk of a heart attack.

Cholesterol Imbalance: Elevated LDL cholesterol (commonly referred to as "bad" cholesterol) and low levels of HDL cholesterol ("good" cholesterol) contribute to the development of atherosclerosis, where plaque accumulates in the arteries. High LDL levels increase the risk of plaque formation, while low HDL levels reduce the ability to remove cholesterol from the arteries, compounding the risk of heart diseases.

Diabetes Mellitus: Diabetes affects approximately 463 million people globally[4] and significantly increases the risk of coronary artery diseases. High blood sugar levels associated with diabetes accelerate atherosclerosis and increase the likelihood of plaque dislodge. People with diabetes are two times more likely to develop cardiac ailments[5] and are likely to experience heart attacks earlier in life compared to non-diabetics.

Smoking: Tobacco use remains a prevalent risk factor for MI, with smokers being two to four times more likely to develop heart disease compared to non-smokers.[6] Chemicals in tobacco smoke damage the lining of arteries, promote the buildup of plaque, and contribute to the formation of blood clots. Quitting smoking reduces the risk of heart attack by up to 50% within one year.[7]

Family History: A family history of premature heart disease (before age 55 in men and before age 65 in women) significantly increases the risk of MI. Genetic factors predispose individuals to conditions such as high blood pressure, high cholesterol levels, and diabetes, all of which elevate the risk of heart attack.

Physical Inactivity: Lack of regular physical activity contributes to obesity, hypertension, and abnormal lipid profiles, which collectively increase the risk of heart diseases. People who engage in 150 minutes of moderate-intensity leisure activity per week have a 14 percent lower risk of coronary heart disease than those who reported no exercise.[8]

Stress: Chronic stress and unhealthy coping mechanisms, such as overeating, excessive alcohol consumption, and smoking, contribute to increased blood pressure, elevated cholesterol levels, and heightened risk of coronary heart diseases.

Impact on Economy Due to CVDs

CVDs put substantial economic burdens, placing financial strain on both individuals and the healthcare system in the United States, highlighting the urgent need for effective prevention and management strategies to mitigate these costs and improve public health outcomes.

The average annual direct and indirect cost of CVD was approximately $407.3 billion in 2018 to 2019.[9]

Direct costs of CVD rose significantly over the years, increasing from about $103.5 billion in 1996 to 1997 to approximately $251.4 billion in 2018 to 2019.[9]

MI is one of the most expensive conditions treated in the US, according to aggregate hospital costs in 2017, accounting for $14.3 billion.[10]

In 2010, MI alone incurred a direct cost of $450 billion following 1.1 million hospitalizations.[11]

MI impacts the US healthcare system profoundly, affecting 6 million individuals annually, causing 300,000 deaths per year, and contributing approximately $40 billion in costs annually.[11]

Industry Trends

The projected growth rate of cardiac monitoring is 5.11% from 2024 to 2029, which suggests that there is a noticeable shift towards prioritizing preventive care and adopting healthier lifestyles as key strategies in managing heart health. This change in mindset recognizes the importance of early intervention and lifestyle modifications in reducing the risk factors associated with MI.

On the services front, several emerging trends are reshaping the landscape of heart disease management:

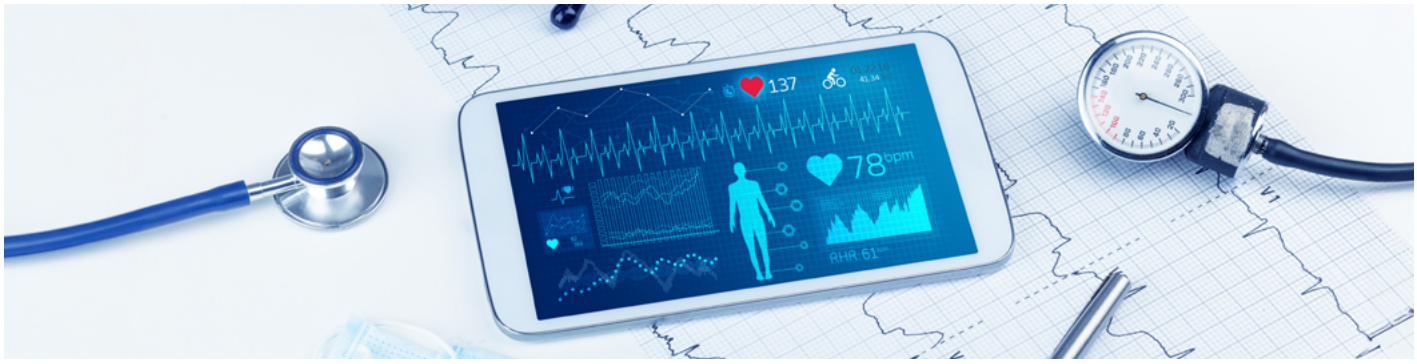
1. **Hospital-at-home Services**: Healthcare providers are increasingly delivering acute medical care traditionally provided in hospitals directly to patients' homes. Hospital-at-home programs offer comprehensive medical services, including monitoring, treatment, and rehabilitation, in a comfortable home setting. This approach enhances patient comfort and convenience while ensuring continuous care and early intervention.

2. **Preventive Care Programs**: Healthcare systems are investing more in preventive care initiatives aimed at educating individuals about heart disease risk factors and promoting healthier behaviors. These programs emphasize regular health screenings, lifestyle counseling, and personalized management plans to reduce the incidence of MI.

3. **Alternative Therapies**: There is growing interest in complementary and alternative therapies, such as acupuncture, yoga, and dietary supplements, as adjunctive treatments for heart health. These therapies are being integrated into comprehensive treatment plans to support traditional medical interventions.

4. **Physiotherapy and Rehabilitation**: Rehabilitation programs focusing on cardiac physiotherapy are gaining prominence. These programs help patients recover from MI and other heart conditions by improving physical strength, endurance, and overall cardiovascular health.

These trends signify a broader shift towards holistic and patient-centered approaches in managing cardiovascular diseases. By combining advanced medical treatments with proactive lifestyle changes and innovative clinical services, healthcare providers aim to improve outcomes, reduce healthcare costs, and enhance the quality of life for individuals affected by heart disease.



Challenges

Functional Challenges

Cost: Applying the new-age healthcare technologies in cardiac patient care involves a lot of gadgets, wearables, home modifications, and other tools that aid in effective data exchange. The costs involved in attaining and maintaining these devices pose a major threat to the effective application of these technologies in economically backward communities. Some nations around the globe are still facing issues with standardized transportation systems and infrastructure resulting in delayed response time even if the distress notifications were sent to the emergency services in case of an event.

Patient Engagement and Behavioral Change: Encouraging patients to adopt heart-healthy behaviors and adhere to treatment plans is challenging due to factors like lifestyle habits, psychological barriers like fear and anxiety, and health illiteracy.

Lack of Health-tech Regulatory Authorities: The lack of regulatory bodies has become a major hurdle in assuring that the health-tech adheres to ethics, patient concerns, confidentiality, and accountability. Even though there are strict measures in place to maintain privacy and confidentiality of the patient's health information, there is always a question of safety and trust about the detailed health history that is being shared. Hacking instances and the lack of stringent action on such scenarios does not build enough trust in the patients to confidently share their health information. Being aware of the importance of cardiac health information, the healthcare applications that use AI to drive their platforms currently do not provide the confidence in addressing the data breach issues.

Multidisciplinary Collaboration: Cardiac care brings together a team of specialists including cardiologists, primary care physicians, nurses, dieticians, psychologists, rehabilitation specialists etc. This cooperation is essential due to the multifaceted nature of CVDs and their management, which often requires expertise from different disciplines to ensure comprehensive care. The challenges include maintaining care continuity across different phases of treatment, ensuring clear communication and coordination among diverse healthcare professionals, and fostering a patient-centric approach. Further involving technology into the setup causes disputes within the team. For example, the solutions suggested by AI might lead to disagreements between the teams as there is still space for inclusion of scientific knowledge base around AI systems.

Technical Challenges

Interoperability Difficulties: This refers to the ability of different cardiac departments like acute care, CCU, rehabilitation, and cardiac physiotherapy to cooperate on exchanging information, as well as integrating and coordinating within and across the departments (GP, pathology, pharmacy, and billing) to provide seamless information portability. But contrasts in data and wording norms can pose a critical hurdle. This is additionally confounded by the presence of both legacy systems and new frameworks, which might have technical impediments on coexistence of care structures.

Fragmented and Unstructured Data: AI depends vigorously on information; however, the accessible data can be inadequate or unstructured. This makes it hard for AI frameworks to provide significant insights. As patient records are confidential, there is always a natural trepidation among the healthcare organizations to exchange health information. Patients as well as users may mistake AI systems for humans and provide consent for detailed data collection, resulting in serious security concerns.

Standardization Issues: Inconsistencies in the information fed to create AI models have a negative impact on the cardiac care, affecting the outcome of diagnosis or treatment. The healthcare organizations are facing issues with standardization of AI governance frameworks, risk management techniques, transparency of AI processes, along with ensuring the privacy and integrity of the patient information.

Technology Adaptation Challenges: With the help of high-dimensional health data and AI models to analyze and process this data, there is a chance to identify the underlying conditions with precision, which are being applied to patient management in real-time. However, health professionals are still not sure that advancements like CDSS (clinical decision support system) would be able to replace the clinicians in critical care because the systems lack situational awareness, and the solutions predicted were based on large databases but do not reflect the target patient population. Thus, it makes it difficult for the medical community to accept, adapt, and trust the AI/ML predicted and proposed algorithms.

AI-led Interventions

The regular monitoring, outpatient visits, or even doctor visits at the doorstep, along with a healthy lifestyle can keep a check on one's cardiac health and help lessen the risk of CVDs. However, the confidence inspired by the precision of treatments and diagnostic capabilities offered by recent technological advances is truly remarkable. These advancements provide patients and doctors with new tools to continuously monitor and assess cardiovascular health at an unprecedented level of accuracy and effectiveness.

If we look at the numbers, the advances in cardiovascular care, including technology-driven interventions and improved management strategies, have contributed to a significant decline in mortality rates from heart disease. Between 1999 and 2019, the age-adjusted death rate from heart disease in the U.S. decreased by approximately 36%.[18]

Artificial Intelligence (AI) emerges as the MVP across diverse domains, catalyzing significant advancements. When it comes to cardiac health, AI isn't just innovative – it's crucial. Some AI-led interventions, illustrating how this technology is transforming cardiac care are:

1. Diagnostic Advances

Technologies such as electrocardiography (ECG/EKG), echocardiography, and cardiac biomarker tests have improved the early detection and diagnosis of cardiovascular conditions, including MI. Early detection allows for timely intervention and treatment, reducing the severity and likelihood of heart attacks.

AI Use Case

AI algorithms can analyze vast amounts of medical data, including ECGs, echocardiograms, and cardiac biomarkers, with greater speed and accuracy than traditional methods. This improves early detection of cardiovascular conditions, helping clinicians intervene earlier to prevent heart attacks.

2. Medical Imaging

Advances in imaging technologies like coronary angiography, computed tomography (CT) angiography, and magnetic resonance imaging (MRI) enable detailed visualization of coronary arteries and cardiac structures. This helps in assessing the extent of coronary artery disease (CAD) and planning interventions to prevent heart attacks.

AI Use Case

AI-powered image analysis in coronary angiography, CT angiography, and MRI scans enhances the interpretation of complex cardiac images. AI algorithms can detect subtle changes indicative of coronary artery disease (CAD) or plaque buildup, aiding in precise diagnosis and treatment planning.

3. Interventional Procedures

Technologies such as percutaneous coronary intervention (PCI) or angioplasty, stenting, and coronary artery bypass grafting (CABG) have revolutionized the treatment of CAD. These procedures can restore blood flow to the heart, reducing the risk of MI, and improving outcomes for patients.

AI Use Case

AI is transforming interventional procedures for CAD by optimizing planning with detailed imaging analysis, providing real-time guidance during procedures for accurate device placement, and aiding clinicians in decision-making based on patient-specific data. Post-procedure, AI monitors recovery and predicts outcomes, enhancing safety and personalized care, thereby improving treatment effectiveness for CAD patients.

4. Telemedicine and Remote Monitoring

Telemedicine platforms and remote monitoring devices allow healthcare providers to monitor patients with cardiovascular conditions more closely, even from a distance. This facilitates early detection of abnormalities or worsening conditions, enabling timely intervention to prevent heart attacks.

AI Use Case

AI algorithms integrated into remote monitoring devices and telemedicine platforms can continuously analyze patient data in real-time. By detecting deviations from normal parameters, AI alerts healthcare providers to potential issues promptly, facilitating timely interventions and preventing complications like heart attacks.

5. Lifestyle Management Tools

Technological tools such as mobile apps, wearable devices (for example, fitness trackers and smartwatches), and online platforms provide individuals with tools to monitor their physical activity, diet, and overall health. These tools and technologies empower individuals to monitor and manage their cardiovascular health proactively and promote healthy lifestyle choices that can prevent cardiovascular diseases.

AI Use Case

AI enhances lifestyle tools like apps and wearables by providing personalized health insights based on user data. It analyzes activity levels, heart rate, sleep, and diet to offer tailored recommendations for better cardiovascular health. AI also identifies behavioral patterns impacting heart health, predicts risks, and enables continuous monitoring, prompting timely adjustments to lifestyle or medical care. This empowers individuals to manage their cardiovascular health proactively, reducing the risk of conditions like MI.

6. Healthcare Operations Efficiency

Healthcare systems worldwide face significant challenges due to high patient volumes, compounded by the burden of administrative tasks.

AI Use Case

AI-powered systems offer a transformative solution by streamlining administrative processes, optimizing hospital workflows, and improving overall operational efficiency in healthcare settings. This technological enhancement enables healthcare professionals to devote more time and attention to patient care, thereby enhancing the quality and accessibility of cardiovascular services.

7. Research and Development

R&D focus on MI represents a crucial frontier in cardiovascular health. It encompasses efforts aimed at advancing our knowledge of the causes, prevention, diagnosis, and treatment of heart attacks, with the goal of improving patient outcomes and reducing the global burden of cardiovascular disease.

AI Use Case

AI accelerates cardiovascular research by analyzing large datasets from clinical trials, genetic studies, and electronic health records. AI-driven insights into disease mechanisms and treatment responses contribute to the development of innovative therapies and preventive strategies against MI.

8. Patient Experience

Ensuring a great patient experience is critical for managing the complex and vulnerable nature of cardiac risk patients. Even seemingly healthy individuals may face cardiac issues due to underlying risk factors and lifestyle habits, highlighting the importance of preventive monitoring.

AI Use Case

While various technologies and comprehensive platforms exist to meet patient needs, integrating AI with UX platforms presents a significant opportunity to elevate patient experience further, particularly through home health monitoring systems. Given that the baby boomer generation experiences the highest incidence of cardiac events, healthcare solutions must be tailored to meet their specific needs, thereby enhancing overall cardiac health management and improving quality of life. AI can help improve the patient-provider experience by using ambient listening devices to transcribe the conversation and translate the encounter to notes to EHR, helping with automated follow-ups, referrals, and further appointment scheduling.

Conclusion:

The cardiac health market is poised for significant growth as advances in medical technology. Increasing prevalence of CVD, aging population and rising awareness in heart health are key drivers propelling demand for innovative solutions.

With the integration of AI powered tools across various stages of the cardiac care continuum, from diagnosis to post treatment care, has made entire field more precise, personalized and effective, eventually resulting in better patient outcomes and efficient healthcare systems.

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