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Implications of AI on Cardiovascular Patients' Routine Monitoring and Telemedicine

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Abstract

Cardiovascular and chronic disease management and treatment are started to incorporate Artificial Intelligence gradually into cardiovascular telemedicine and remote monitoring. Through the use of AI technologies, patients are much benefited, and at the same time, it promotes improvement in patients, examination, and continuous monitoring. Since the use of AI forefront in its role as a monitoring technique, predictive analytics, risk factors and detail personal medication in zone of cardio vascular diseases, this paper dwells on one how cardio vascular care is evolving with experimental use of AI. It also describes the limitation and challenge of AI use, for instance, around data privacy, legal regime and data quality, and AI moral decisions such as the disposition of openness and trust. Nevertheless, the current demands require future development in cardiology –telemedicine with the use of artificial intelligence in prescriptive and predictive cardiology based on precision medicine, machine learning, and genomic as well as electronic health records data. Therefore, the following aspects should be addressed to overcome the present challenges to the effective functioning of AI in the healthcare segment of cybersecurity threats, data connections, and accessibility. Therefore, the paper's conclusion about the subject AI obversive points to the potential for a full-scale revolution in the sphere of cardiovascular care with regards to the patient's outcomes and accessibility and effectiveness on the international level under conditions of further regulation as well as technological enhancement.

Keywords: AI & health, telemonitoring, cardiovascular telemedicine, risk analytics, personalized medicine, data privacy, ethical issues, ethical concerns, precision, healthcare technologies, patient outcomes, EHRs, genomics.

INTRODUCTION

The WHO states clearly that CVD accounts for nearly 31% of the global mortality; in aggregate, they are the main causes of death and diseases. Primogeny, diseases of the advancement age for example high calorific intake and lethargy, smoking, and ageing all boost the rate of CHD. It is important in health care delivery especially in cardiovascular diseases because they are conditions that need close monitoring all the time and have such focal characteristics as early diagnosis and treatment. Some of the patients were forced to frequent clinics or hospitals more frequently especially for cardiovascular output and management [4]. This may be expensive, delay prone and at times inconceivable for patents who are in remote or disadvantaged community. Telemedicine and more specifically, remote monitoring technology, has taken cardiovascular care to an entirely new level because of the ability to effectively provide the option to eliminate major discomfort, cost and accessibility challenges associated with out of the clinical patient monitoring.

Telemedicine is defined as the practice of availing medical services by means of telecommunication engineering whereby patient is able to speak to an expert in person without having to physically meet him/her over a distance using facilities like phones. Among innovative solutions for the mentioned type of healthcare, it is possible to distinguish real-time or asynchronous teleconsultations, distant diagnosis, telemonitoring. The aim of remote monitoring though is to systematically monitor specific status of a particular patient for instance blood pressure, pulse, EKG [2]. By allowing patients to get care in their homes, cost and rates of admittance to hospitals are reduced by telemedicine and monitoring. These models of remote healthcare delivery that have however been enhanced as indicated in the paper have however been enhanced through the integration of artificial intelligence. Numerous authorities perceive that the application of the AI technology may reform the cardiovascular field through gives better accuracy, productivity, & efficacy of the diagnosis and management with the help of intricate algorithms & machine learning. Supervised under the application of devices at a distance, details obtained from big data, collected from such devices, can be analyzed by an AI which can provide diagnosis, can detect patterns

or something unusual that has happened, to the doctors. Consequently, the AI systems in question can in early and better prevention of some of the cardiovascular events like heart attacks or strokes, and arrhythmia [3]. The Physicians also benefits from applying AI driven solution since these assist in enhancing the decisions made, the patient treatment delivery and reduced work on aspects that entail repetitive work.

Another reasonably well-known trend of using AI in cardiovascular treatment is is its usage in conjunction with telemedicine and remote supervision. Especially in case with the AI apps incorporated to the mobile apps and wearable technologies, a steady data input from the patients' gadgets and biosensors can be fed to the facilitating physicians in real time. This makes it possible for medical practitioners to identify shifts in health/condition of the patient in order to prevent worsening of the condition as corrected by the patient before they sick [4]. In that aspect, given that the applications can give feedback to the consumer and give the consumer a link to their healthcare providers in real-time when needed, the applications have that possibility of empowering the consumer to own their health. However, all the said opportunities have some limitations that can be mentioned as challenges of employing AI for cardiovascular telemedicine and remote monitoring. It is, therefore, vital to pose some questions that should be addressed insofar as; data privacy/ protection, data security, and data or information ethical use in the application of artificial intelligence in the healthcare industry is concerned. This is also raising the efficacy of AI algorithms and this simply means that the AI applicative used in a therapy context needs to be verified to an even higher degree. At the same time, the same approaches are regulating the efficacy of applying AI technology in healthcare [5].

In this paper, we shall particularly consider how the AI application can assist in telemedicine and remote patient monitoring of cardiovascular patients. Next will be the current state using AI solutions used in members telemedicine systems, pros / cons of those solutions and in future on how AI may further improve care for cardiovascular related diseases. In our opinion, the results of this work will contribute to revealing how AI is reshaping the practice of cardiovascular medicine and we emphasize the need for ongoing improvement of this direction [6].

A CONSIDERATION OF THE CONCEPTS OF TELEMEDICINE AND REMOTE MONITORING

Two of the most recent technologies are telemedicine and remote monitoring that have transformed the healthcare industries especially with regards to the diagnosis and treatment of many ailments among them chronic illnesses such as heart ailments. These communicate individual status, care, and health using Information Communication Technology, telecommunications and health informatics have supported patient status, health care and overall system performance dimensions besides supporting patients' access to health care. These have received importance as the cardiovascular diseases (CVDs) to an extent mostly require quick treatment and continuing follow-up to evade catastrophic sequels such as heart attacks, strokes, and other critical events [7].

Healthcare Remote Monitoring: Remote monitoring is a way of getting information from patients using measurement and telecommunications technology outside clinics or hospitals. After that this data is transmitted on to the health care workers for response and examination. The aspects of tracking and reporting composes parameters of the life cycle, such as heart rate, blood pressure, blood oxygen, and ECG; pre- weight indices that are vital for the evaluation of the heart function; and the cardiovascular profile [8]. These vitals can be taken by the patients themselves and in real time by wearing devices, sensors, or home-monitoring systems, this will afford the caregivers a chance to attend to the patients without having to meet them physically often and frequently.

Telemonitoring is the technique of having permanent near observation of a patient without intervening which becomes beneficial to the healthcare workers because they are able to observe changes in the patient's condition. For example, it can use notification to ensure that a timely response is made in case a patient pressure or pulse for example is beyond an expected range. Patients with chronic cardiovascular diseases, including hypertension, chronic heart failure, or any other arrhythmias that need constant assessment for symptom control and signs of complication, can have their conditions enhanced by remote supervision. In addition there is an experienced doctor's command, and remoteness, the patient gets much more freedom in choosing the line of treatment and a direct control over the illness, which leads to high rates of patient compliance [9].

Healthcare Telemedicine: Telemedicine on the other hand is described as the delivery of health care services through information communication technology in the form of applications like; secured messaging, video and telephone consultations. In that, they do not have to attend actual clinic or hospital; they can do diagnosis, treatment and even consultation with their patients. Telemedicine is suitable for a first appointment consultation, after attending a follow up appointment there are consultations, mental health therapy, and prescription and sickness

management. That is why telemedicine is a good method of receiving cardiovascular treatment through a contact with the cardiologists from home [10]. This will of particular need to patients who reside in areas that lack facilities that can enable them receive specialized care or in the rural setting. By delivering telemedicine services, time has been salvaged, costs have been cuts and wait time has been eradicated limiting the patient's geographical constraints. Since patients can speak to a doctor, get a medicine from him or have a check-up without requiring to meet a doctor or occupy a hospital or clinic's time and space, it lessens the stress on the medical facilities and therefore improves the efficiency of the general healthcare system.

Another advantage of the telemedicine convenience for a tool is that cardiovascular patients receive prompt consultations. Chest pains or irregular heartbeats patients can telephone their doctors and discuss what they can do as they may need to alter their tablets, diet or have another scan. This also include results assessment and planning of the treatment due to follow up contacts and necessary changes in telemedicine [11].

The Partnership between Telemedicine and Remote Monitoring: Despite the differences mentioned above, telemedicine and remote monitoring are synergistically linked since they can deliver multifaceted and, indeed, virtually all-encompassing model of cardiovascular healthcare. Indeed, data such as these are captured from the patients, or from such devices such as the monitors, asynchronously and transmitted to the healthcare givers. As we explained before, communicating via facility-blabla soft phones during telemedicine consultations, clinicians can talk with the patient, study all the results, and select the kind of therapy. These technologies alone make it possible for caregivers to provide anticipatory, participative, and personalized care which are two of the fundamental components of chronic cardiovascular disease management [12]. For instance, patient suffering from hypertension can use home blood pressure monitor to report some prescribed measurements to the doctor. A telemedicine appointment may be scheduled to search for the possible causes and to assess the potential modifications that may be done to the therapy if the data gathered indicate that, indeed, the patient has consistently high blood pressure reading. Likewise, a cardiologist could work at a distance with a data that a patient with heart failure collected; the patient's heart rate and fluid level, for example, through a wearable device. The candidate should be able to assess whether the dosage of the medicine should be adjusted, or if clinic visit is required based on information and sign [13].

Obstacles and Restrictions: Although telemedicine and remote monitoring provide a lot of benefits in managing cardiovascular disease few disadvantage also exist. The technology used in these devices is not demanding as it only requires a relatively low level of technical skills and internet connection in a patient's home although some patients may have a difficulty with this. Since health information that is in the process of being transited through computers is required to be safeguarded from the increasing incidents of cyber crises and risks, data security and privacy issues are still relevant. It is admitted that not all of the cardiovascular care can be conducted through telemedicine, and especially in emergency situations when a body and face-to-face assistance are needed. However, going through these challenges has been beneficial as several patients' healths resulting from the integration of telemedicine and remote monitoring into cardiovascular treatment has improved [14]. These technologies increase the degree of patient's observation, shorten the number of days that patients passing through the hospital, and help identify potential outcomes and their management in cardiovascular diseases.

Telemedicine and remote monitoring are the tools which improve cardiovascular prognosis by providing contact with a professional and consistent supervision. Other and general advantages of such progress include enhanced patient engagement, disease detection, and accessibility which all are essential for cardiovascular illnesses. Thus, it is assumed that they will become an essential tool to face the constantly augmenting global cardiovascular diseases burden when incorporating them in the ordinary clinical practice as technologies develop and spread [15].

THE ROLE OF AI FOR THE MONITORING OF CARDIOVASCULAR PATIENTS POLL

There is nothing more revolutionary in the context of the current healthcare industry than AI Assisted Remote Monitoring of Cardiovascular Patients. AI is enhancing specificity, quality, and speed of delivery of cardiovascular care through monitoring big data, pattern recognition and prediction [16]. AI solutions, especially, are transforming remote monitoring systems as doctors get immediate time-stamped views, risk analysis, and working advice relating to patients with cardiovascular illnesses.

AI-Powered Real-Time Data Analysis Algorithms: AI is found to be useful in the remote monitoring of cardiovascular patients since it can analyze information obtained from various wearable's, sensors and Home Monitoring Equipment used on patients. These gadgets determine other important CV parameters including body weight, pulse rate, blood pressure, ECG, and oxygen level in the blood. In many cases the information collected

from these devices is huge, complex and streaming, making it difficult and labor intensive to analyze manually. It is in such a situation that an AI excels [17]. Such large files can then be rapidly analyzed using AI and especially ML/DL models to flag similarities and differences from other instances, inclusions, and omissions. For instance, AI can analyze ECG data to look for abnormal heand rhythms that are also known as arrhythmias like AFib or atrial fibrillation that could, if are not treated, cause stroke.

AI can also track changes in blood pressure over the course of an hour or a day, search for signs of hypertensive crisis and notify practitioners when a patient is at risk, even if said patient does not appear to be uncomfortable yet. The identification of intervention needs to halt adverse cardiovascular events is time-sensitive a feat made possible by the real-time data analysis [18]. Big data analytics enhance the ways cardiovascular diseases are diagnosed through artificial intelligence. For example, deep learning algorithms are now capable of analyzing imaging data such as MRI and echocardiographic studies providing near perfect assessment of the state of heart functions, and identifying potential problems such as valvular diseases, coronary artery diseases, and congestive heart failure. By automating these processes, doctors can pay an emphasis on using AI derived knowledge in decision making which in turn elevates the overall quality of patient care [19].

AI-Powered Predictive Analytics for Cardiovascular Event Early Detection: Of all the advantages of using AI, the ability to predict falls under one of the most crucial in remote monitoring of cardiovascular patients. AI can predict the chances of certain cardiovascular events or health deteriorations even as they occur by assessing past data as well as data of the present day. The use of real patient information such as demographics of patients, real-time biosignatures/vital signs, patient medical history including facts related to nutrition and exercise to build large data sets are the core of predictive analytics models. Looking at rhythm or motion activities, for instance, blood pressure and heart rate, or ECG, AI systems can predict possible cardiovascular occurrences such as heart attacks, stoke and congestive heart failure. It can lead to preventive actions, such as change of medication, alteration to lifestyle, or a clinic appointment in order to do a further assessment of the identified risk factors [20]. Because with the chronic cardiovascular disease such as heart failure, hypertension, and coronary artery disease, early treatment is critical to general prognosis, this predictive method is crucial. Due to taking into consideration of patient's genetic characteristics, a family history, and other peculiarities, the AI, in this case, may give an individual prognosis. Thanks to such a high degree of individualized care, AI is able to tailor interventions for every patient because it enhances the effectiveness of the treatment.

Examples of AI-Powered Cardiovascular Remote Monitoring Case Studies: Various successful implementation of the cardiovascular remote monitoring has been used to explain the effect of the application of AI in the field. Wearable devices based on AI for monitoring heart rate, with simultaneous electrocardiograms, for example, has shown high efficacy in detecting the presence of arrhythmia such as AFib [21]. In one of the trials, patients in the AFib group received real-time signals of their condition using wearable ECG connected to artificial intelligence to identify earlier the onset of stroke and prevent it. These smart devices keep on tracking the unwanted cardiac rhythms, and does remind patients and health care providers so that early intervention can be made. Smartphone application that uses AI to track blood pressure and other cardiovascular information is still another instance.

It will use artificial intelligence to predict the likelihood of issues from hypertension from the patient. Such applications may reduce the load of poorly controlled hypertension that is a crucial risk factor for cardiovascular disease and stroke since the application recommends unique changes, and the blood pressure values are reported in real time to the patient [22]. It has also been employed into telehealth services where it deals with patient details then proceeds to recommend treatment to medical practitioners for remote consultations. In a sense, the AI tools also help doctors sort their patients by data to prioritize high-risk issues so that these can be attended to first. Further, by providing recommendations using the big clinical databases and patient's individual characteristics AI can help healthcare providers in rationalizing the operational decisions.

Improving Clinical Workflow and Decision-Making: Apart from the better patient outcomes, the Health care involvement of AI assists medical staff by working to reformat medical care processes and choices. AI provides real time alert/decision support to the physicians by assessing and analyzing data such as biometric data obtained from wearable and physiological monitoring devices, patient history, electronic health record and test reports [23]. This means data takes less time to analyze and healthcare professionals have more time to make significant decisions. Such aspects can be, for example, the automated determination of dangerous patterns in the patient's health condition, such as the sudden rate increase, or high blood pressure, that would allow doctors to pay special attention to these patients right away. In addition, AI can help with clinical decision support systems (CDSS) to assist health care givers decide on the right course of action for a patient's treatment plan. Superior and enhancing with fresh data AI models, overall, increases the standard of treating cardiovascular patients [24].

Quite uniquely, due to the combined information processing feature of AI, healthcare professionals can track many patients simultaneously. Given the fact that AI allows for a real-time tracking regime with minimal interference from clinicians, it is especially important for the management of vast patient volumes. They may thus efficiently keep tabs with the patients, ensure certain responses are taken as soon as possible, and reduce the amount of face-to-face interaction. Remote monitoring is changing tile way cardiovascular patients are diagnosed, managed and treated by providing a more efficient, preventive, and personalized approach to cardiovascular diseases [25]. AI opens the doors for the possible complete overhaul of cardiovascular care from the monitoring and interpretation of dynamic data to using data analytics to inform clinical judgment. Remote monitoring on the basis of artificial intelligence is on the verge of becoming one of the powerful tools in the unceasing war against cardiovascular diseases due to the possibilities for timely diagnosing of health issues and optimizing of treatment plans facilitating patients' outcomes. It's possible that as AI advances and is integrated into the delivery of cardiovascular care in a more comprehensive way that it will have a positive impact on the delivery of care and the costs of care in the future.

AI IN COMBINATION WITH TELEMEDICINE FOR CARDIOVASCULAR DISEASES

Cardiovascular care is evolving as a result of blending telemedicine with artificial intelligence (AI) in terms of how they are delivered rather than in terms of the outcomes produced, which remain concrete. AI technologies are very helpful when used with telemedicine systems because they allow doctors to easily diagnose and treat problems with the cardiovascular system; they also make patient care more active, tailored to each patient, and efficient. Both the patients and clinical practitioners are reaping big from this synergistic effect especially in dealing with chronic cardiovascular diseases such as heart failure, hypertension, and arrhythmias [26].

AI and Telemedicine Convergence in Cardiovascular Care: Especially since the COVID-19 pandemic, telemedicine has become very popular, as it allows healthcare professionals to deliver care from a distance, via video calls, phone calls, or group or individual messaging. Telemedicine has the advantage of implying cardiovascular care with the comfort of home and this is ideal for people living in the rural areas or those in wheel chairs [27]. However, even if telemedicine is available, the latter has a number of disadvantages even as a separate method. While valuable and feasible for many applications, most traditional teleconsultations may lack robust means of tire deep patient data analysis depending on clinicians' capacity to assess health data in real time.

AI enters the picture here. AI can analyses health data in a real time and help doctors to make proper decisions during an online consultation if telemedicine platforms integrate it with itself. For instance, blood pressure monitor, heart rate monitor, ECG wearable devices are examples of remote monitoring devices whose information can be analyzed by an AI model. This information may be used by the attending medical professional during a teleconsultation where such advanced systems can quickly churn out data for medical professionals such as the patient's current status, among others. This elevates the quality of service delivery since the various decisions that have to be made during the consultation process are based on the most accurate and up to date information. Also. by allowing patients to use chatbots virtual assistants and other automated systems in their management processes AI can also help enhance telemedicine systems [28]. Some of these solutions based on artificial intelligence (AI) can help to schedule appointments, remind patients to take their medicine and even conduct preliminary consultations to gather key health statistics. This improves clinical efficiency and patient satisfaction since practitioners are able to focus in on aspects of care that are going to have a bigger impact in a patient's life.

Enhancing Telemedicine Diagnostics with AI: AI is even more transformative in diagnosis in telemedicine. Cardiovascular diseases very often require additional diagnostic tests such as ECG, echocardiography, and blood tests, which in most cases are only possible via an in-person visit. However, in a telemedicine, context AI can enhance diagnostics and make processes involved more efficient. Accompanying algorithms that can analyse ECG data in real-time have been designed to detect many types of arrhythmias and identify potential heart disease such as atrial fibrillation or myocardial infarction [29]. For example a patient may present an ECG read out through a wearable device or home monitoring application during a telemedicine consultation. With AI, it is possible to analyze various ECG mappings looking for arrhythmias or any other peculiar patterns and provide the practitioner with an interpretation pointing at problems that may be needing a solution. This increases the diagnostic accuracy and reduces the necessity of subjective analysis most likely to generate human error. The same is true for analyzing many patient data and matching them to vast clinical databases to reveal trends and risk factors unnoticeable by human vision. Due to this AI is a powerful instrument in early detection of cardiovascular diseases symptoms that could easily go unnoticed hence early interventions [30].

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AI IN HEART DISEASES

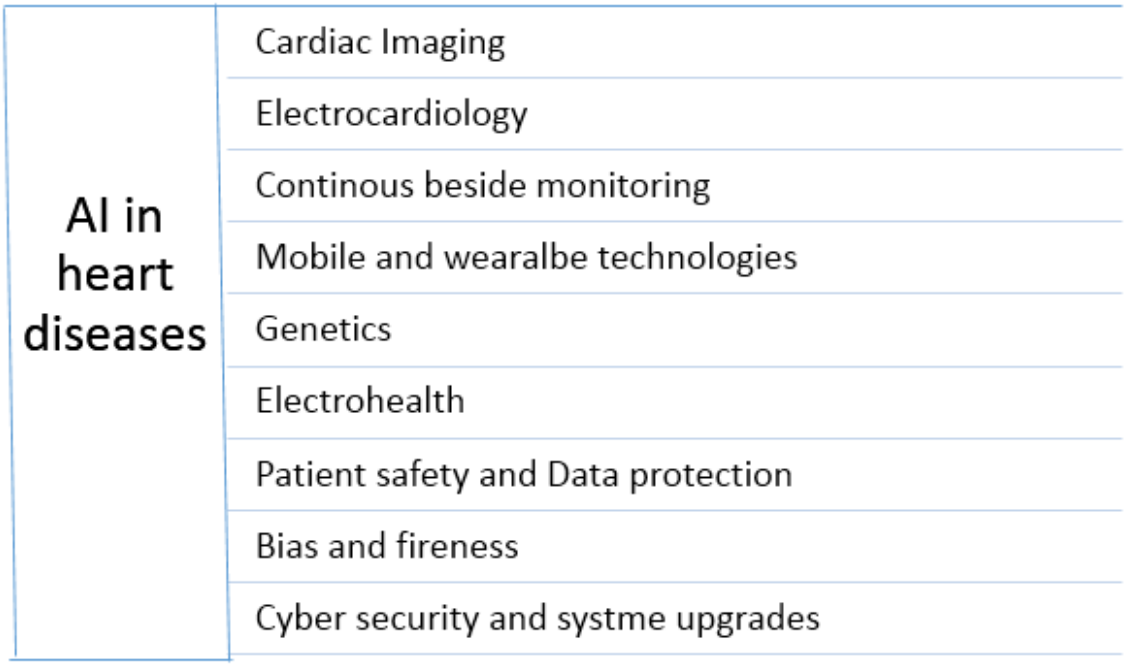

Figure 1 showing AI in heart diseases

AI-Driven Customized Therapy Programs: Personalized treatment is one of the major advantages of application of AI in conjunction with telemedicine in cardiovascular disease management. Cardiovascular disease does not lend itself to an 'off the shelf' approach to its management. Since patients are individuals who make up different characteristics that influence the treatment plan such as DNA, habits and history. Using clinical practice guidelines, medical literature evidence, and population data, along with patient-specific information, the AI method is more specific. For example, proposing the adequate drug or treatment, AI can look at a patient's history of BP fluctuations, their genetic predisposition to a heart disease, and their reaction to previous treatments [31].

Telemedicine practitioners are able to arrive at the best of the options they have during a telemedicine session in that the AI weighs down options on the basis of the patient's information. It is very helpful when dealing with chronic cardiovascular diseases, particularly when it comes to long-term treatment when medication non-compliance is likely to have serious ramifications: uncompensated heart failure, for example, a stroke. Technology enhanced telemedicine systems are capable of monitoring patients through time and make necessary adjustments to patients' treatment plans over time. For instance, particular variations in the treatment and lifestyle may be detected in the case of a patient with the hypertension; should their blood pressure rise and become higher than normal, the potential for a change is to be discussed with the doctor in the subsequent virtual consultation [32]. One of the major opportunities of utilizing AI in telemedicine is the dynamic, real-time character that increases the protection of cardiovascular incidences as doctors can promptly and effectively manage changes in treatment in the dynamic flow of patients' course.

Improving Patient Involvement and Adherence: AI integration in telemedicine improves the patient adherence and interaction with technology as well as helps health care professionals. People suffering from cardiovascular disease and those with chronic issues have a tendency of not adhering to medical advice and or adopting changes in their way of life. Telemedicine applications with AI can enable clients to offer personalized information, use signals to remind the necessary treatment, and offer materials to enhance patient adherences to the appropriate standard treatment protocols. For example, applications built on the artificial intelligence can record the eating habits; record the level of physical activity; or remind the patient when to take his medications among other things that will help him or her change his or her actions. They can also provide feedback to patients in real-time depending on their monitoring data that their AI-powered virtual assistants are tracking. For instance, they can remind patients that their heart rate is high or blood pressure is low and what they should do, maybe call their doctor [33]. AI systems can also answer patient questions on their specific cardiovascular disease and recommend

ways of effectively coping with symptoms involving the provision of patient health education materials. This way, the knowledge gap is solved and this increases patients' participation in their treatment; has been proven to improve patient's health status and reduce hospital re-admission.

Nevertheless, there are several challenges that limit the extensive application of telemedicine with the assistance of AI methods in cardiovascular practice. However, before all these technologies become part of the firm's healthcare system, there is a number of key challenges which must be addressed; chief among these is the issue of privacy and security, along with the need for compliance with regulatory standards [34]. Also, correctness assurance is required, as AI algorithms have to be accurate in providing dependable, secure, and efficient treatment. Finally, it is still a challenge to bridge the digital divide because some patients do not have a device, reliable internet connection or even simply the ability to navigate on the telemedicine apps. It is now clear that the future of telemedicine depends greatly on AI. Future enhancements of AI algorithms, data analytics, and machine learning, and other methodologies will enhance the prospects of cardiovascular care with increased feasibility and efficacy in more precise and unique plans of treatment. In the future, it is likely that the AI will simply be incorporated into electronic health records (EHRs), where it will become even easier for healthcare workers to acquire and assess real time patient data during teleconsultations [35].

The integration of telemedicine organizational elements with AI produces better patient involvement, enhanced care delivery, more accurate diagnostics, and personalized therapy for cardiovascular medicine. With the help of AI, healthcare providers are now able to satisfy some of the patient's demands from the distance by collecting data in real time, performing analysis and making predictions, as well as by individual approaches developed accordingly any patient [36]. As more effective and efficient means of delivering treatment with proven benefit to patient health and decreased expenditures on healthcare, AI applications have the potential for increasing the quality of cardiovascular care as these technologies advance and become further integrated into telemedicine platforms.

THE BENEFITS OF AI IN REMOTE MONITORING AND CARDIOVASCULAR TELEMEDICINE

AI implementation in cardiology telemedicine and remote monitoring expresses several impacts that are beneficial for the patients and the care givers. AI is needed to reconcile the fact of attaining better results in cardiovascular treatment through increasing the efficiency of telemedicine and distance monitoring, becoming more personalized, precise, swift, and open. These advantages will therefore always be significant in the treatment of such chronic cardiovascular conditions as hypertension, heart failure, and arrhythmias, especially when decision making is dependent on ongoing observation and timely intervention to prevent outcomes that are often catastrophic. The below is the summary of the main benefits that AI brings into the remote monitoring and the cardiology telemedicine service [37].

Better Cardiovascular Condition Early Detection: Among all the advantages of utilizing, cardiovascular telemedicine, increasing the efficiency of identifying cardiovascular diseases at early stages is probably the most beneficent effect improved by the help of AI. Electronic devices like the blood pressure cuff, home ECG monitors, wearable or smart watches can generate huge amounts of data that fed into the AI system to identify an infinitesimal change in the patient's health status. This way, before the patient feels any signs of cardiovascular disease, these devices will pick on potential signs, for instance high blood pressure or irregular heartbeat. For instance, deep learning opportunities are particularly suitable for detecting cardiac dysphrhmias such as AFib, a known cardiac condition which, if left untreated, poses risk of stroke [38]. In cases of AFib, or other abnormalities, wearable device obtained heart rate and ECG data can be quickly analyzed by AI models, and the results relayed to the patient and healthcare provider. Incorporation of AI for early differential diagnostic procedures ensures efficient early treatments and therapies before there are risks of severe critical events such as heart attacks or strokes.

Constant, Real-Time Surveillance: AI enhances continuing assessment of cardiovascular patients and their condition in real-time without the need to visit medical facilities repeatedly. Some key basic health indices such as blood pressure, oxygen level, weight and pulse can be regularly monitored through use of devices that are synchronized with artificial intelligence [39]. For this reason, the medical professionals are always on the look for their patients' illnesses and are in a position to look for any warning symptoms that may necessitate immediate action. Live monitoring is especially valuable for patients with chronic cardiovascular disorders, including hypertension or chronic heart disease. For instance, you have the opportunity for the AI system to detect the changes in the blood pressure measurements over time and be able to alert the doctors when the readings are outside acceptable thresholds. It makes them react before the case gets out of hand and this reduces hospitalization and strengthens the likelihood of positive results in the long term.

Individualized Care and Treatment Programs: In prudent application of patient health information, AI is crucial in fine-tuning cardiovascular patient treatment plans. Cardiovascular diseases often require an individual approach to treatment since each patient's individual genetic profile, habits, past medical history, and current health parameters shape this disease [40]. All of it can be done using AI and some parts could be prescribed using evidence from big data and clinical guidelines for treatment options in patients with similar conditions. AI, for example, by evaluating consecutive blood pressure readings can identify how the client with hypertension is responding to the medicine. AI can take this information and suggest some changes in the everyday life or adjustments to the medication intake routine to the patient's condition. This degree of personalization improves treatment results because patients have confidence that their intercessions are appropriately aligned with their conditions. AI can also help medical professionals to define the optimal drugs combinations, to predict potential interactions and calculate the probability of side effects in cardiovascular treatment [41].

Enhanced Clinical Efficiency and Decision-Making: In cardiovascular telemedicine, AI enhances decision making in clinical practice through providing medical practitioners with valuable patient data from the large database. For effectiveness in real-time decision making support, AI algorithms can analyze health data from various sources including laboratory reports, clinical protocols, patient's data, health records, and wearable devices. This reduces the burden of handling data manually by helping healthcare providers to make right decisions in record time. For instance, the clinicians can sort the patients on the basis of the nature and intensity of their diseases with the help of AI based decision support system [42]. AI can alert doctors that a patient with cardiovascular disease is worsening, for example through having rising blood pressure or heart rate. Thus, by minimizing process-driven interactions, manual workflow adjustments, and extracting doctors from superb ovine engagements to focus on key occurrences, it raises therapeutic throughput. AI also assists in the pattern of care, which reduces variation and the chance for human error on clinical judgment.

Improved Self-Management and Patient Involvement: The skills of AI-based telemedicine and remote monitoring therefore include the principle of actively engaging the patient, and giving out timely feedback and health tips on such aspects and issues as patient health. For example, cardiovascular patients often fail to adhere to prescribed dietary restrictions, take multiple medications, or live up to prescribed exercise regimens because they forget, do not understand, or find it hard to remember various regimens and discrete medication and changes in diet [43]. Thus, AI can help in issues like providing positive reinforcement to patients in maintaining a healthy lifestyle, tracking results of attempts in controlling cardiovascular risk factors, and reminding patients on times when it's appropriate to take their medicines. An example of an AI incorporated into a feature in a mobile health application – will complete a prescription or a blood pressure check daily for the patient.

Further, the system could present teaching materials in the form of printed information describing the positive impacts of Fab 5 on cardiovascular health including diet, exercise, and weight management. AI systems can engage patients and help them make informed choices regarding their own treatment by basing responses off the patient's data in real-time, improve self-empowerment and thus, create an attitude of personal responsibility for the patient's health. AI also enables patients to avail themselves of consultations through video conferencing or secure message from a distance. Concerns can be raised, questions posed, and advice sought conveniently without physically visiting a clinic owing to such high level of accessibility to patients. The communication input level does not only ensure patients remain active participants in their long term management, it also improves the relationship between the patient and the physician [44].

Lowering Medical Expenses and Enhancing Resource Distribution: This in turn permits healthcare elevation and averts pointless hospitalizations, and guides to improved distribution of resource, making cardiology telemedicine and remote monitoring artificial intelligence financially beneficial. When constant remote monitoring is performed, several face-to-face encounters, which could be costly both to patients and health care practitioners, are not as needed. Also, AI avoids people having to go to emergency and hospital care because they detected early symptoms that could lead to significant complications. AI systems can even list patients that require a particular care order based on the severity of their conditions permitting efficient utilization of healthcare necessities [45]. API allows healthcare practitioners to address larger population extents of patients without necessarily compromising the quality of services by the мік reducing repetitive tasks such as data analysis and monitoring. The end-effect is benefits to cost in the healthcare system since more population can access cardiovascular services sustainably.

Other benefits include enhanced early diagnosis, continuous watch, personalization of care, enhanced clinic decision making, patient engagement, and treatment cost reduction [46]. HL specialists may be able to diagnose patients with cardiovascular diseases—particularly those who have chronic illnesses which require extensive attentions and re-evaluations by the system—more rapidly, validly, and effectively with AI. AI will most likely

have an even greater role in the future of cardiovascular telemedicine since this field will definitely progress as it positively affects patient outcomes, decreases costs, and flips the approaches to the delivery of cardiovascular care.

IMPLEMENTING AI FOR CARDIOVASCULAR TELEMEDICINE AND REMOTE MONITORING: OBSTACLES AND RESTRICTIONS

While applying AI into cardiology telemedicine and remote monitoring can revolutionize patient care as a whole in principle, there are several pain points and limitations that should be discussed to highlight the specific challenges one has to face in order to smoothly implement AI into the practice. Several technical issues, ethical, regulatory, and social challenges may limit its potential in treating cardiovascular disease. In order to advance the potential of identified solutions to enhance integration, and to provide possibilities for the advancement in the quality of cardiovascular patients' care it is necessary to understand these challenges [47].

Data Security and Privacy Issues: The two major challenges of artificial intelligence in telemedicine and remote monitoring involve data security and privacy. Cardiovascular data is some of the most sensitive data; therefore, negligence or infringement may lead to dire consequences for patients, including fraud and identity theft, wrong treatment due to changes or loss of usable information. Only remote monitoring remains vulnerable because it continuously collects and sends new data about blood pressure, pulse, ECG, other vital signs [48]. Unfortunately AI systems can raise the risk of such breaches if they are not properly protected as they rely on cloud storage and related digital applications.

Therefore, the following measures should be employed to minimize such risks enhanced encryption methods, secure channels, and sound information technologies measures. Best practices for patient data protection are prescribed by regulations that include the HIPAA in the United States. But to follow these regulations might be quite challenging especially when the AI platforms used are operating in multiple territories that have different privacy legal frameworks. There is one apparent problem: ensuring that the AI apps are not vulnerable to data breaches and meet these standards [49].

Problems with Data Standardization and Quality: The quality and reliability of the data input to the creation of artificial intelligence algorithms are important. The quality of data collected through cardiovascular telemedicine and remote monitoring may be dependent on the type of equipment being utilized, the patient's compliance and the environment in which the data is obtained. For instance, the blood pressure cuffs or wearable ECG monitors may produce inaccurate measurements, which may complicate the kind of data fed to AI and in turn may reduce the ability of AI to diagnose or predict accurately. Cardiovascular data is collected in a number of ways which includes imaging systems, wearable technology devices, and records. Perhaps such data sources are not clean or structured enough for the integration into AI systems. Lack of compatibility between the different platforms and devices might prove challenging in training the AI models leading to analyses that are either inadequate or of questionable dependability [50]. Since the chance of spoiling the beneficial results achieved in cardiovascular disease with AI based treatment increases with the geographical distance between the doctor and patient, making the equipment reliable, constant and consistent with AI algorithms requires emphasis.

Legal and Regulatory Difficulties: The regulation of AI within healthcare is still evolving at this time. As mentioned above, such authorization and application of AI technologies in medicine are under the processes of regulation by various organizations internationally including the EMA, FDA and others. The systematic classification of AI systems, the corresponding approval processes, and the ongoing monitoring of these systems once they are applied in a health care context is generally very unclear. This is particularly true in cardiovascular telemedicine when patient lives are at risk and time for a decision is critical. For example, it can be that regulatory agencies tend to categories deep learning algorithms that detect anomalies in ECGs or estimate risks of a heart attack as medical devices, which entails rigorous approval processes [51]. AI growth often leaves the regulatory authorities lagging behind, approving or underspecifying current legislation each time the development of new technology accelerates. Moreover, there raises again some questions about the attribution of responsibility in the case the system performed a wrong action (like misdiagnosis). Who is at fault when the result is negative: the AI developer or the healthcare provider or both? The applicability of AI in cardiology telemedicine is limited by legal and regulatory uncertainties in these areas [52].

AI Trust and Ethical Issues: The ethical concern regarding the use of AI in health care is not lacking in any way; such concern is evident, especially in sensitive sub-fields in cardiovascular care. Also known as the black boxes AI systems especially those that apply machine learning entail decision-making mechanisms that are complex and hard for the patients or the doctors to understand. It also means that when AI is used to come up with important judgments on diagnosis or treatment regime, this lack of explain ability could greatly compromise the trust between

the patient and the health care givers [53]. For instance an AI system may, for example, recommend a course of therapy for a patient with cardiovascular disease based on data trends whereas a doctor may have a hard time trusting the recommendation unless the clear thinking is explained. On the same note, patients can feel uncomfortable when they consider AI as being a large part of their treatment; if they do not understand how the software works or if they believe that the computer is going to put the healthcare provider out of business. To address such concerns, AI researchers should focus on building more explanations that could be understood by doctors about the working of the AI system. Another aspect is to build awareness and perception of AI to reduce the perception of AI as a threat and an additional guarantee that AI is a tool and not a threat to human experts in cardiovascular diseases can also be done by creating awareness to patients and Heath care providers on the benefits and shortcomings of AI in cardiovascular care [55].

Digital Literacy and Patient Access: AI-supported cardiovascular telemedicine and remote monitoring require utilizing digital tools and internet connection. However, not all patients can have internet connection or the devices for remote monitoring treatment. The availability and use of AI based healthcare interventions may be significantly limited for people who reside in rural areas, are of very old age or low economic standing. These may comprise of absence of digital literacy particularly by the older individuals that could struggle to add new technology, absence of internet connectivity or inability to acquire smartphones or wear able devices [56]. Unless these technologies are deployed across the population, the transformative cardiovascular care made possible by AI might deepen existing inequalities in patient access to care. Some of the possible approaches include the enhancement of the availability and affordability of healthcare technologies, and patient training in the use of alternative interface technologies as well as testing A/I application across a diversity of subject populations [57].

Integration with Traditional Healthcare Systems: AI in cardiovascular telemedicine needs to be compatible with the existing structures if it is to be useful. However, a significant number of healthcare organizations in the world still use paper charts, obsolete software, or departmental information management systems [58]. This absence of compatibility between the AI apps and the conventional health care systems can lead to challenges of sharing data and information use in real time leading to poor coordination while making treatment plans for the patients. To overcome this challenge, there has to be more substantial improvements in funding for enhancement of healthcare Facilities and guaranteeing that the AI can interface with Electronic Health Records, Telehealth applications and other fundamental structures. In particular, interoperability appears as a central issue to deliver an individualized approach to patients since clinicians need to promote a global vision of patients, including data from artificial intelligence driven remote monitoring [59].

Although telemedicine and remote monitoring involving cardiovascular diseases has a lot of advantages with the help of Artificial Intelligence a number of obstacles and restrictions should be overcome to make it effective. Another important concept known as risk can also be defined as problems that need to be addressed in managing EHR and includes data privacy, regulatory approval ethical issues, accessibility issues, and the problem of system integration. This paper explained that as the healthcare sector accepts the use of AI in curative practices, working together with the remaining players, that is, the healthcare providers, the developers, regulators, and patients, these challenges have to be conquered [60]. Thus, it is possible to identify four major areas for taking AI forward, effectively helping it to realize the potential of bringing positive changes to cardiovascular illnesses on a global scale: accessibility, efficiency and effectiveness, as well as personalization of cardiovascular care for patients.

EXPLORING THE POSSIBILITIES, DEVELOPMENTS AND NEW POTENTIALITIES OF AI IN CARDIOVASCULAR TELEMEDICINE AND REMOTE SURVEILLANCE

Telemedicine and remote monitoring of cardiovascular disease has benefited from application of AI and this is just the beginning of improved care approaches in the future [61]. That is why there are so many developments and trends being introduced with the help of AI technologies, which will improve the further work in the sphere of cardiovascular diseases. Most of these future development will not only improve the diagnosis and treatment of cardiovascular diseases by enhancing the usage of AI but also will optimize the healthcare delivery system for better patient outcome. Here are the following future innovation/ direction in the roles of AI for cardiovascular telemedicine/ remote monitoring:

Advanced AI Models for Predictive Analytics and Risk Assessment: The second future development likely to be seen in cardiovascular telemedicine through AI is the elaboration of sophisticated predictive analysis. Today, analytical applications of AI allow for the diagnosis of cardiovascular events based on the range of data about patients [63]. Nevertheless, as the AI technology advances, the mentioned predictive models will be far more detailed and capable to estimate a lot of other factors and the outcomes will be much more precise. For instance,

the future AI system may contain records of findings and results of genomic studies, data collected by wearable health monitoring devices and other aspect of the human environment, and that include one's diets, exercise, et cetera. Merging all this information should be possible in AI models; thus, risk predictions for individuals can be given in real-time allowing for early interventions and customizing the prevention strategies to fit the individual patient risk levels [64]. This will change cardiovascular management from an acute model where a patient has to have a cardiovascular event before healthcare providers can attend to them, to a more preventive model.

Enhanced Personalization of Treatment Plans through AI and Machine Learning: In the future, the role for AI applications in the cardiovascular field is going to rise significantly–personalized treatment. AI can be subdivided by ML where systems adapt to learn from the patient data and get better with time. This will make it possible for the doctors and other health care providers to deliver individualized treatment programs based on the persons' genotype, lifestyle, and history, and results of certain therapy attempts [65]. For example, in cardiovascular patient domain, AI systems will be capable of examining vast base in patient outcomes to determine which medications, interventions, or lifestyle changes provide optimum results for patients of certain characteristics. In the case of chronic diseases such as heart failure or hypertension AI may assist with determining the optimal medication or diet which the patient could adhere to to achieve an optimal lifelong health [66]. Advanced AI systems shall also incorporate means of modifying treatments in real-time depending on new data collected by remote monitoring devices implying that pratique shall remain relevant over the course of the patient's progression.

Integration of AI with Genomics and Precision Medicine: Another allied field of genomics, which has addressed the role of genes in phenomenon of health and disease, is likely to again be more integrated with applied AI in cardiology. AI will also be used on matters to do with genetics and cardiovascular diseases by helping analyze the large volumes of genomic data we are likely to gather in the near future. Holistically, AI can learn large volumes of genomic data and from these, recognize a specific genetic make that correlates to heart diseases, hypertension, arrhythmias, and other cardiovascular diseases [67]. Their integration into genomics might enhance the concept of precision medicine for cardiovascular disease by offering highly personalized treatment. For example, AI could suggest to clinicians how some elements of a patient's DNA would make them respond to specific medications. There are moves toward precision medicine, thereby enable the healthcare providers to give optimum intercession, thereby reducing side effects and increasing intercession efficiency [68].

AI-Driven Remote Monitoring and Virtual Care Expansion: The evolution of cardiovascular telemedicine will mean the further development of more extensive uses of remote care through more highly developed AI systems. Remote monitoring systems will become more intelligent and supply continuously real-time data and patients' data; consequently, it will introduce intelligent alarms for healthcare providers when necessary [69]. Furthermore, wearable devices can be smart watches and fitness trackers, AI could connect with other modern surveillance technologies, for example, implantable devices, or home-based diagnostic tools in order to monitor cardiovascular health with even greater accuracy and constantly [70]. For instance, AI could monitor data collected from an implanted pacemaker and, for instance, identify instances such as arrhythmia or a faulty device, and report to the care team in good time. The next phase of growth for telemedicine will be even more convenient for patients and physicians [71]. Real-time diagnostic support from AI when clients are on virtual consultations will be a plus since virtual consultation decisions will be more comprehensive and accurate. It could also filter patient information as well as their signs and symptoms and even suggest a diagnosis or course of action for the clinicians to take while on virtual consultations [72].

Real-Time Integration with Electronic Health Records (EHRs): Computer and AI interaction with Electronic Health Record systems will experience further advances in the future years, which will enhance organizations' ability to obtain a full view of the patient. EHRs are currently fragmented where details could be located in different systems and AI already has applied to ensure that such data is made more interoperable and easier to access. In the future, new patient information from devices or home monitoring will be synchronized in real time to enable their intelligent update in the patient's record whenever a new remote consultation has been conducted [73]. When more of this data is compiled, healthcare providers will be able to make better decisions and offered higher quality care. For instance, if a patient's heart rate or blood pressure recorded from a wearables device falls outside certain safety limits, the AI may notify this information and write into the EHR, for use during the next consultation [74]. It could also be of great help to clinicians by monitoring the patient records and recommending possible means of providing preventive measures or alarms for similar incidents on the basis of records and clinical rationales. Ideally, due to the more direct connection with EHRs, consumers of AI will also find it convenient in terms of the effective and efficient functioning of clinicians' workflow in the delivery of care.

AI in Cardiovascular Imaging and Diagnostics: Echocardiography, CT scan, MRI and other cardiovascular imaging tests are used in the diagnosis of cardiovascular diseases. In diagnostics based on medical imaging, AI is expected to help in faster and accurate interpretation of the images. Hyper specialized machine learning known as deep learning can classify images in the medical domain better than the naked eye, thanks to their neural networks [75]. Cardiovascular imaging; TeleHealth consults; Future use of advanced AI systems will include real – time monitoring of cardiovascular imaging during consults. For instance, the AI system can playback an echocardiogram and summarize it for the clinician by pointing out such features as valve disorders, dysfunctioning heart muscles or other cardiovascular problems. This would help to decrease the time needed to analyses the imaging results in order to provide a correct diagnosis as well as minimize the role of human factor [76].

Ethical AI and Enhanced Patient Trust: AI is still in the process of development and as it grows more attention will be paid to the manner in which it is being developed and implemented in cardiovascular care. It is vital for patients and the healthcare providers themselves to understand why an AI system made a particular decision and comprehensible AI models will be nonnegotiable. The future development will be XAI frameworks to the AI systems, which will explain to the clinicians how the systems arrived at the specific suggestions they provide hence promoting trust in AI systems [77]. They are going to design AI systems with integrated rules of ethics to make sure that individuals are not going to misuse the innovative systems. This range from; fair approach for algorithms and artificial intelligence, equality in forms of healthcare, and control and privacy of patients. The use of AI in cardiovascular telemedicine and remote monitoring has a promising future, and a number of innovations are expected to be made on the horizon, which will probably enhance the patient outcomes and reduce the healthcare costs and reform the delivery system [78]. The use of AI in the future will only expand within the context of RF, in areas such as predictive analytics, individualized treatments, incorporating genomics, remote surveillance, and supplying diagnosis through imaging. Nonetheless, the possibilities of AI to revolutionise CV healthcare are vast, and the forthcoming decade should be expected to exhibit progressive enhancement of the technology for the general enhancement of healthcare delivery to patients and healthcare givers.

CONCLUSION

The application of cardiovascular care has been revolutionized with the introduction of the use of Artificial Intelligence in cardiovascular telemedicine and distant monitoring. AI has many benefits that positively contribute to patient and health system successes, including permitting ongoing real-time surveillance and early identification enhancements and enhancing patient relations and individualized treatment planning. The technology is valuable for the treatment of chronic diseases including heart failure, hypertension, and arrhythmia because it allows improved diagnosis, timely treatment, and reduction of cardiovascular events. The use of AI in cardiovascular practice has pros but, challenges cannot be neglected. These include the issues of confidentiality, legal uncertainty, professionalism, and technology accessibility for a number of population groups. Challenges that healthcare organizations face while integrating informatics and technology include the lack of data standard, cybersecurity risks that are common and comprehensiveness of strong regulations that are needed for assimilation of technology. In addition, addressing concerns of Machine learning overtaking human decision making, being transparent or in a way promoting trust in the technology arealso still key to its widespread use.

Further evolution of cardiovascular telemedicine is expected to provide even more thrilling enhancements withania. This will in turn enable more precise personalization of treatment planning, real time EHR integration, as well as enhanced predictive modelling enabling a more preventative cardiovascular treatment approach. Though innovative in diagnosis and imaging through artificial intelligence, there emerges immense potential for AI complemented by genomics and Precision medicine for targeting cardiovascular diseases at a depth that has never been attempted. But here the points of ethical, technological, and regulatory characteristics should be worked out if these trends are to fully emerge. In sum, there is immense potential for the total revolution of cardiovascular treatment as an efficient, accessible and individualized process through the aid of AI. Cardiovascular telemedicine and remote monitoring seem promising due to the constant development of AI technologies advanced research on applied, legal, and ethical concerns. This change will be made possible by the application of what is referred to as AI in health care delivery; the tools required to improve patient outcomes, reduce costs and transform the practice of cardiovascular medicine around the globe.

REFERENCES

1. Banafa, A. (2024). Introduction to artificial intelligence (ai). CRC Press.
2. Byrne, M. F., Parsa, N., Greenhill, A. T., Chahal, D., Ahmad, O., & Bagci, U. (2023). Ai in clinical medicine: A practical guide for healthcare professionals.
3. John Wiley & Sons. Cohen, S. (2020). Artificial intelligence and deep learning in pathology. Elsevier Health Sciences.
4. Comito, C., Forestiero, A., & Zumpano, E. (2022). Integrating artificial intelligence and iot for advanced health informatics: Ai in the healthcare sector. Springer Nature.
5. Pillai, A. S. (2023). Artificial intelligence in healthcare systems of low-and middle-income countries: Requirements, gaps, challenges, and potential strategies. International Journal of Applied Health Care Analytics, 8(3), 19–33.
6. Arif, A., Khan, A., & Khan, M. I. (2024). Role of AI in Predicting and Mitigating Threats: A Comprehensive Review. *JURIHUM: Jurnal Inovasi dan Humaniora*, *2*(3), 297-311.
7. Packt Publishing Ltd. Soufiene, B. O., Chakraborty, C., & Almalki, F. A. (2023). Practical artificial intelligence for internet of medical things: Emerging trends, issues, and challenges.
8. Srinivasu, P. N. (2022). Computational intelligence and machine learning approaches in biomedical engineering and health care systems. Bentham Science Publishers.
9. Vayena, E., Ferretti, A., Benatar, S., & Brock, G. (2021). Big data and artificial intelligence for global health. Global Health: Ethical Challenges, 429.
10. Kuan PX, Chan WK, Ying DKF et al. Efficacy of telemedicine for the management of cardiovascular disease: a systematic review and meta-analysis. Lancet Digit. Heal. 4, e676–e691 (2022).
11. Benzinger L, Ursin F, Balke W-T, Kacprowski T, Salloch S. Should artificial intelligence be used to support clinical ethical decision-making? A systematic review of reasons. BMC Med. Ethics 24, 48 (2023).
12. Nagarajan VD, Lee S-L, Robertus J-L et al. Artificial intelligence in the diagnosis and management of arrhythmias. Eur. Heart J. 42, 3904–3916 (2021).
13. Ricci RP, Morichelli L, D'Onofrio A et al. Effectiveness of remote monitoring of CIEDs in detection and treatment of clinical and device-related cardiovascular events in daily practice: the HomeGuide Registry. Eur. Eur. pacing, arrhythmias, Card. Electrophysiol. J. Work. Groups Card. pacing, arrhythmias, Card. Cell. Electrophysiol. Eur. Soc. Cardiol. 15, 970–977 (2013).
14. Varma N, Epstein AE, Irimpen A, Schweikert R, Love C. Efficacy and safety of automatic remote monitoring for implantable cardioverter-defibrillator follow-up: the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST) trial. Circulation 122, 325–332 (2010).
15. Hindricks G, Taborsky M, Glikson M et al. Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): a randomised controlled trial. Lancet (London, England) 384, 583–590 (2014).
16. Hindricks G, Varma N, Kacet S et al. Daily remote monitoring of implantable cardioverter-defibrillators: insights from the pooled patient-level data from three randomized controlled trials (IN-TIME, ECOST, and TRUST). Eur. Heart J. 38, 1749–1755 (2017).
17. Crossley GH, Boyle A, Vitense H, Chang Y, Mead RH. The CONNECT (Clinical Evaluation of Remote Notification to Reduce Time to Clinical Decision) trial: the value of wireless remote monitoring with automatic clinician alerts. J. Am. Coll. Cardiol. 57, 1181–1189 (2011).
18. Amara W, Montagnier C, Cheggour S et al. Early detection and treatment of atrial arrhythmias alleviates the arrhythmic burden in paced patients: the SETAM study. Pacing Clin. Electrophysiol. 40, 527–536 (2017).
19. Ferrick AM, Raj SR, Deneke T et al. 2023 HRS/EHRA/APHRS/LAHRS expert consensus statement on practical management of the remote device clinic. Hear. Rhythm 20(9), e92–e144 (2023). doi:10.1016/j.hrthm.2023.03.1525.
20. Russo V, Cante L, Imbalzano E et al. The impact of COVID-19 pandemic on hospitalization and interventional procedures for cardiovascular diseases during the first wave in Italy. Int. J. Environ. Res. Public Health 20(1), 472 (2022).
21. Russo V, Rapacciuolo A, Pafundi PC et al. Cardiac implantable electronic devices replacements in patients followed by remote monitoring during COVID-19 lockdown. Eur. Hear. Journal. Digit. Heal. 2, 171–174 (2021).
22. Rosier A, Gentils M, Durand J, Bensaber A. Potential impact of a new generation of remote monitoring platform: evaluation of the yearly triage burden for 35 595 patients. Eur. Heart J. 42, ehab724.3098 (2021).

23. Khan, M. I., Arif, A., & Khan, A. (2024). AI's Revolutionary Role in Cyber Defense and Social Engineering. *International Journal of Multidisciplinary Sciences and Arts*, *3*(4), 57-66.
24. Khan, M. I., Arif, A., & Khan, A. R. A. (2024). AI-Driven Threat Detection: A Brief Overview of AI Techniques in Cybersecurity. *BIN: Bulletin Of Informatics*, *2*(2), 248-261.
25. Andersen GN, Haugen BO, Graven T, Salvesen O, Mjolstad OC & Dalen H. Feasibility and reliability of point-of-care pocket-sized echocardiography. European Journal of Echocardiography 2011 12 665–670. (https://doi.org/10.1093/ejechocard/jer108)
26. Lafitte S, Alimazighi N, Reant P, Dijos M, Zaroui A, Mignot A, Lafitte M, Pillois X, Roudaut R & DeMaria A. Validation of the smallest pocket echoscopic device's diagnostic capabilities in heart investigation. Ultrasound in Medicine and Biology 2011 37 798–804. (https://doi.org/10.1016/j.ultrasmedbio.2011.02.010)
27. Michalski B, Kasprzak JD, Szymczyk E & Lipiec P. Diagnostic utility and clinical usefulness of the pocket echocardiographic device. Echocardiography 2012 29 1–6. (https://doi.org/10.1111/j.1540-8175.2011.01553.x)
28. Biais M, Carrie C, Delaunay F, Morel N, Revel P & Janvier G. Evaluation of a new pocket echoscopic device for focused cardiac ultrasonography in an emergency setting. Critical Care 2012 16 R82. (https://doi.org/10.1186/cc11340)
29. Prinz C, Dohrmann J, van Buuren F, Bitter T, Bogunovic N, Horstkotte D & Faber L. Diagnostic performance of handheld echocardiography for the assessment of basic cardiac morphology and function: a validation study in routine cardiac patients. Echocardiography 2012 29 887–894. (https://doi.org/10.1111/j.1540- 8175.2012.01728.x)
30. Fukuda S, Shimada K, Kawasaki T, Fujimoto H, Maeda K, Inanami H, Yoshida K, Jissho S, Taguchi H, Yoshiyama M, et al. Pocket-sized transthoracic echocardiography device for the measurement of cardiac chamber size and function. Circulation Journal 2009 73 1092–1096. (https://doi.org/10.1253/circj.CJ-08-1076)
31. Mjolstad OC, Dalen H, Graven T, Kleinau JO, Salvesen O & Haugen BO. Routinely adding ultrasound examinations by pocketsized ultrasound devices improves inpatient diagnostics in a medical department. European Journal of Internal Medicine 2012 23 185–191. (https://doi.org/10.1016/j.ejim.2011.10.009)
32. Panoulas VF, Daigeler AL, Malaweera AS, Lota AS, Baskaran D, Rahman S & Nihoyannopoulos P. Pocket-size hand-held cardiac ultrasound as an adjunct to clinical examination in the hands of medical students and junior doctors. European Heart Journal Cardiovascular Imaging 2013 14 323–330. (https://doi.org/10.1093/ehjci/jes140)
33. Abe Y, Ito M, Tanaka C, Ito K, Naruko T, Itoh A, Haze K, Muro T, Yoshiyama M & Yoshikawa J. A novel and simple method using pocket-sized echocardiography to screen for aortic stenosis. Journal of the American Society of Echocardiography 2013 26 589–596. (https://doi.org/10.1016/j.echo.2013.03.008)
34. Furukawa A, Abe Y, Ito M, Tanaka C, Ito K, Komatsu R, Haze K, Naruko T, Yoshiyama M & Yoshikawa J. Prediction of aortic stenosis-related events in patients with systolic ejection murmur using pocket-sized echocardiography. Journal of Cardiology 2017 69 189–194. (https://doi.org/10.1016/j.jjcc.2016.02.021)
35. Gustafsson M, Alehagen U & Johansson P. Imaging congestion with a pocket ultrasound device: prognostic implications in patients with chronic heart failure. Journal of Cardiac Failure 2015 21 548–554. (https://doi.org/10.1016/j.cardfail.2015.02.004)
36. Phillips CT & Manning WJ. Advantages and pitfalls of pocket ultrasound vs daily chest radiography in the coronary care unit: a single-user experience. Echocardiography 2017 34 656–661. (https://doi.org/10.1111/echo.13509)
37. Russell FM, Ehrman RR, Cosby K, Ansari A, Tseeng S, Christain E & Bailitz J. Diagnosing acute heart failure in patients with undifferentiated dyspnea: a lung and cardiac ultrasound (LuCUS) protocol. Academic Emergency Medicine 2015 22 182–191. (https://doi.org/10.1111/acem.12570)
38. Nishigami K. Point-of-care echocardiography for aortic dissection, pulmonary embolism and acute coronary syndrome in patients with killer chest pain: EASY screening focused on the assessment of effusion, aorta, ventricular size and shape and ventricular asynergy. Journal of Echocardiography 2015 13 141–144. (https://doi.org/10.1007/s12574-015-0265-1)
39. Carlino MV, Paladino F, Sforza A, Serra C, Liccardi F, de Simone G & Mancusi C. Assessment of left atrial size in addition to focused cardiopulmonary ultrasound improves diagnostic accuracy of acute heart failure in the emergency department. Echocardiography 2018 35 785–791. (https://doi.org/10.1111/echo.13851)

40. Arif, A., Khan, M. I., & Khan, A. (2024). An overview of cyber threats generated by AI. *International Journal of Multidisciplinary Sciences and Arts*, *3*(4), 67-76.
41. Esposito R, Ilardi F, Schiano Lomoriello V, Sorrentino R, Sellitto V, Giugliano G, Esposito G, Trimarco B & Galderisi M. Identification of the main determinants of abdominal aorta size: a screening by pocket size imaging device. Cardiovascular Ultrasound 2017 15 2. (https://doi.org/10.1186/s12947-016-0094-z)
42. Cavallari I, Mega S, Goffredo C, Patti G, Chello M & Di Sciascio G. Hand-held echocardiography in the setting of pre-operative cardiac evaluation of patients undergoing non-cardiac surgery: results from a randomized pilot study. International Journal of Cardiovascular Imaging 2015 31 995–1000. (https://doi.org/10.1007/s10554-015- 0656-4)
43. Khan HA, Wineinger NE, Uddin PQ, Mehta HS, Rubenson DS & Topol EJ. Can hospital rounds with pocket ultrasound by cardiologists reduce standard echocardiography? American Journal of Medicine 2014 127 669.e1–669.e7. (https://doi.org/10.1016/j. amjmed.2014.03.015)
44. Bhavnani SP, Narula J & Sengupta PP. Mobile technology and the digitization of healthcare. European Heart Journal 2016 37 1428–1438. (https://doi.org/10.1093/eurheartj/ehv770)
45. Chow CK, Ariyarathna N, Islam SM, Thiagalingam A & Redfern J. mHealth in cardiovascular health care. Heart, Lung and Circulation 2016 25 802–807. (https://doi.org/10.1016/j.hlc.2016.04.009)
46. Eapen ZJ, Turakhia MP, McConnell MV, Graham G, Dunn P, Tiner C, Rich C, Harrington RA, Peterson ED & Wayte P. Defining a mobile health roadmap for cardiovascular health and disease. Journal of the American Heart Association 2016 5 e003119. (https://doi.org/10.1161/JAHA.115.003119)
47. Tarakji KG, Wazni OM, Callahan T, Kanj M, Hakim AH, Wolski K, Wilkoff BL, Saliba W & Lindsay BD. Using a novel wireless system for monitoring patients after the atrial fibrillation ablation procedure: the iTransmit study. Heart Rhythm 2015 12 554–559. (https://doi.org/10.1016/j.hrthm.2014.11.015)
48. Williams B, Lacy PS, Baschiera F, Brunel P & Dusing R. Novel description of the 24-hour circadian rhythms of brachial versus central aortic blood pressure and the impact of blood pressure treatment in a randomized controlled clinical trial: the Ambulatory Central Aortic Pressure (AmCAP) Study. Hypertension 2013 61 1168–1176. (https://doi.org/10.1161/HYPERTENSIONAHA.111.00763)
49. Brooks GC, Vittinghoff E, Iyer S, Tandon D, Kuhar P, Madsen KA, Marcus GM, Pletcher MJ & Olgin JE. Accuracy and usability of a self-administered 6-minute walk test smartphone application. Circulation: Heart Failure 2015 8 905–913. (https://doi.org/10.1161/CIRCHEARTFAILURE.115.002062)
50. Tison GH, Sanchez JM, Ballinger B, Singh A, Olgin JE, Pletcher MJ, Vittinghoff E, Lee ES, Fan SM, Gladstone RA, et al. Passive detection of atrial fibrillation using a commercially available smartwatch.
51. Seto, E. (2019). Cost Comparison between Telemonitoring and Usual Care of Heart Failure: A Systematic Review. Telemedicine and e-Health, 25(6), 1-9.
52. Klersy, C., et al. (2021). Effect of Telemonitoring of Cardiac Implantable Electronic Devices on Healthcare Utilization: A Meta-Analysis of Randomized Controlled Trials in Patients with Heart Failure. European Journal of Heart Failure, 23(3), 1-9.
53. World Health Organization. (2017). Telemedicine: Opportunities and Developments in Member States: Report on the Second Global Survey on eHealth 2009. WHO Press?
54. American Heart Association. (2018). Telemedicine: Opportunities and Challenges in Cardiovascular and Stroke Care: A Scientific Statement from the American Heart Association. Circulation, 138(1), 1-22
55. Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. The Lancet, 380(9836), 37-43.
56. Bashshur, R. L., Shannon, G. W., Krupinski, E. A., Grigsby, J., & Kvedar, J. C. (2011). National telemedicine initiatives: essential to healthcare reform. Telemedicine and e-Health, 17(8), 1-9.
57. Buntin, M. B., Burke, M. F., Hoaglin, M. C., & Blumenthal, D. (2011). The benefits of health information technology: a review of the recent literature shows predominantly positiveresults. Health Affairs, 30(3), 464-471.
58. Burke, B. L., Hall, R. W., & Section on Telehealth Care. (2015). Telemedicine: Pediatric applications. Pediatrics, 136(1), e293-e308
59. Carretero, S., & Stewart, J. (2019). The impact of telemedicine on delivery of care: A review of meta-analyses. Critical Reviews in Oncology/Hematology, 135, 20-36.
60. Khan, M. I., Arif, A., & Khan, A. R. A. (2024). The Most Recent Advances and Uses of AI in Cybersecurity. *BULLET: Jurnal Multidisiplin Ilmu*, *3*(4), 566-578.

61. . Hailey D, Paquin M-J, Casebeer A, Harris LE, Maciejewski O. Evidence about tele-oncology applications and associated benefits for patients and their families. J Telemed Telecare. 2006; 12:40–3. https://doi.org/10.1258/135763306779379941 .
62. Sonu B, Sian B, Kumar CV, Anil A, Alma N, Saltanat K, et al. Telemedicine across the globeposition paper from the COVID-19 Pandemic Health System Resilience PROGRAM (REPROGRAM) International Consortium (Part 1). Front Public Health. 2020; 8:644. https://doi.org/10.3389/fpubh.2020.556720.
63. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019; 25:44–56.https://doi.org/10.1038/41591-018-0300-7.
64. Pacis DM, Subido ED Jr, Bugtai NT. Trends in telemedicine utilizing rtificial intelligence. AIP Conf Proc. 2018; 13:1933. https://doi.org/10.1063/1.5023979 .
65. Faes L, et al. A clinician's guide to artificial intelligence: how to critically appraise machine learning studies. Transl Vis Sci Technol. 2020; 9:7. https://doi.org/10.1167/tvst.9.2.7 .
66. Anderson M, Anderson SL. How should AI be developed, validated and implemented in patient care? AMA J Ethics. 2019; 21(2):E125–30. https://doi.org/10.1001/amajethics.2019.125 .
67. Meskó B, Marton G. A short guide for medical professionals in the era of artificial intelligence. NPJ Digit Med. 2020; 3:126. https://doi.org/10.1038/s41746-020-00333-z
68. Downing NL, Bates DW, Longhurst CA. Physician burnout in the electronic health record era: are we ignoring the real cause? Annals of Internal Medicine. 2018; https://doi.org/10.7326/M18-0139.
69. Roshan M, Rao A. A study on relative contributions of the history, physical examination and investigations in making medical diagnosis. J Assoc Physicians India. 2000;48(8):771–5
70. Bhaskar S, Bradley S, Sakhamuri S, Moguilner S, Chattu VK, Pandya S, et al. Designing futuristic telemedicine using artificial intelligence and robotics in the COVID-19 era. Front Public Health. 2020; 8:708. https://doi.org/10.3389/fpubh.2020.556789.
71. Mathews SC, McShea MJ, Hanley CL, Ravitz A, Labrique AB, Cohen AB. Digital health: a path to validation. NPJ Digit Med. 2019; 2:38. https://doi.org/10.1038/s41746-019-0111-3
72. American Medical Association. Augmented intelligence in health care. 2019. https://www.ama-assn.org/system/files/2019-08/ai-2018-board-policy-summary. Pdf. Accessed10Nov2020
73. Horton MB, Brady CJ, Cavallerano J, Abramoff M, Barker G, Chiang MF, et al. Practice guidelines for ocular telehealth-diabetic retinopathy. Telemed J eHealth. 2020; 26:495–543.
74. Li JPO, Liu H, Ting DSJ, Jeon S, Chan RVP, Kim JE, et al. Digital technology, tele-medicine and artificial intelligence in ophthalmology: a global perspective. Prog Retin Eye Res. https://doi.org/10.1016/j.preteyeres.2020.100900
75. Fernandes JG. Stroke prevention and control in Brazil: missed opportunities. Arq Neuropsiquiatr. 2015; https://doi.org/10.1590/0004-282X20150127
76. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2018; 49:e46–99. https://doi.org/10.1161/STR.0000000000000163
77. Agrawal K, Raman R, Ernstrom K, Claycomb RJ, Meyer DM, Hemmen TM, et al. Accuracy of stroke diagnosis in telestroke-guided tissue plasminogen activator patients. J Stroke Cerebrovasc Dis. 2016; 25: 2942–6. https://doi.org/10.1016/j.jstrokecerebrovasdis.2016.08.009.
78. Ali F, Hamid U, Zaidat O, Bhatti D, Kalia JS. Role of artificial intelligence in TeleStroke: an overview. Front Neurol. 2020; 11:559322. https://doi.org/10.3389/fneur.2020.559322
79. Vagal A, Wintermark M, Nael K, Bivard A, Parsons M, Grossman AW, et al. Automated CT perfusion imaging for acute ischemic stroke. Neurology. 2019; 93:888. https://doi.org/10.1212/WNL.0000000000008481
80. Soun JE, Chow DS, Nagamine M, Takhtawala RS, Filippi CG, Yu W, Chang PD. Artificial intelligence and acute stroke imaging. Am J Neuroradiol. 2020; https://doi.org/10.3174/ajnr.A6883
81. Albers GW, Marks MP, Kemp S, et al. Thrombectomy for stroke at 6 to 16 hours with selection by perfusion imaging. N Engl J Med. 2018; 378:708–18
82. Nagel S, Sinha D, Day D, et al. e-ASPECTS software is non-inferior to neuroradiologists in applying the ASPECT score to computed tomography scans of acute ischemic stroke patients. Int J Stroke. 2017; 12: 615–22.
83. Guberina N, Dietrich U, Radbruch A, et al. Detection of early infarction signs with machine learning-based diagnosis by means of the Alberta Stroke Program Early CT score (ASPECTS) in the clinical routine. Neuroradiology. 2018;60:889–901

84. Kauw F, Heit JJ, Martin BW, van Ommen F, Kappelle LJ, Velthuis BK, et al. Computed tomography perfusion data for acute ischemic stroke evaluation using rapid software: pitfalls of automated postprocessing.JComputAssistTomogr.2020;44:75–7.https://doi.org/10.1097/RCT.0000000000000946
85. Finnane A, Dallest K, Janda M, Soyer HP. Teledermatology for the diagnosis and management of skin cancer: a systematic review. JAMA Dermatol. 2017; 153:319–27.
86. Esteva A, Kuprel B, Novoa RA, et al. Dermatologist level classification of skin cancer with deep neural networks. Nature. 2017; 542(7639):115–8. https://doi. org/10.1038/nature21056.