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Chapter 7

Artificial intelligence in chronic disease management: Proactive solutions for long-term care

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Abstract

AI is transforming chronic disease management by providing proactive solutions for long-term care. By analyzing patient data, AI enables early detection, personalized treatment plans, and continuous monitoring. These advancements improve patient outcomes, reduce hospitalizations, and support more efficient, data-driven management of chronic conditions like diabetes and cardiovascular diseases.

Keywords

AI, Chronic Disease, Long-Term Care, Monitoring, Personalized Treatment, Proactive Solutions

7.1. Introduction

Chronic disease management is an increasingly relevant field within the healthcare ecosystem, primarily due to the growing prevalence of chronic conditions globally. Successful management entails the implementation of strategies that are able to mitigate the disease-related symptoms and compensate for the deficiency of the organ or system in the human body. Before complications arise, curative strategies should supplement preventive care. Chronic diseases, if untreated, contribute to deteriorating the patient's health and quality of life and increase the demand for healthcare services, thus depleting healthcare resources (Syed, 2021). The goal of chronic disease management is to improve care to limit the disease's harmfulness and treat the complications resulting from it.

In this narrative, the potential of artificial intelligence to contribute to and affect the evolution of chronic disease management will be discussed. The paper aims to provide a comprehensive review of AI applications in long-term disease care management and to present future approaches to AI that can be used to classify potential directions and efforts in this area. The paper's main points include the design of an AI application determined by the different pain assessment methods in the geriatric patient cohort, as well as details and revealed evidence on such AI systems with advanced technology. Well-designed AI solutions offer potential improvements to provide patient comfort relief after an intervention for chronic orthopedic diseases. However, this narrative is intended to highlight the potential implementation of AI throughout various long-term care settings, and future directions will mirror this aspect of the review.

7.1.1. Background and Significance of Chronic Disease Management

1.1.1. Report of the 1st Section Chronic diseases, also called non-communicable diseases (NCDs), are a substantial and increasing public health burden. In 2009, worldwide, 14.5 million people between the ages of 30 and 70 died from one of the four primary NCDs (cardiovascular diseases, diabetes, chronic respiratory diseases, and cancer). More than 30 million people suffer from long-term conditions in England alone, a number that is predicted to increase by five percent over the next decade. Chronic diseases demand specialist management to avoid complications that increase patient numbers and stretch resources. A model for chronic disease management (CDM) is the prevention of complications and associated acute illness by the development of specific prediction algorithms and the provision of associated preventions. Over the longer term, such solutions, as well as providing better outcomes for patients, such as slowing disease progression and reducing the number of days of hospitalization, are also cost-saving.

Many specific chronic conditions have their management guidelines, focused on the steps that should be taken at different levels of severity. Typically, they involve a large amount of self-management as patients have little day-to-day contact with clinicians. To support this, healthcare providers often delegate the responsibility of management from consultants to non-physicians and increasingly to general paraprofessional personnel. Integrated care uses multidisciplinary teams to care for patients across different settings to provide the right care, in the right place, in a timely fashion. Specialist disease management, plus integrated care to help when complications happen, will be the experience of many. Such a process will be easier for the patient if the different components link together to provide more patient-centered care, or even better, provide individualized support in a community. Depression, anxiety, and fatigue are generally present at two to three times greater rates in patients with long-term conditions. Pulmonary conditions are also typically slowly progressive, and patients can remain independent with the appropriate support. This complexity is demanding an increased number of staff, including physiotherapists and social services, all supported by the GP with incentives for improving patient care. Good practices of this kind are being implemented slowly and in a limited manner (Syed et al., 2021). The current acute hospital inpatient-focused system remains largely unchanged. There is a need for innovation as a matter of national priority. The five-year forward view of the NHS points to the huge challenge facing the NHS with this kind of financing. This report asks the question of whether AI may hold some of the answers.

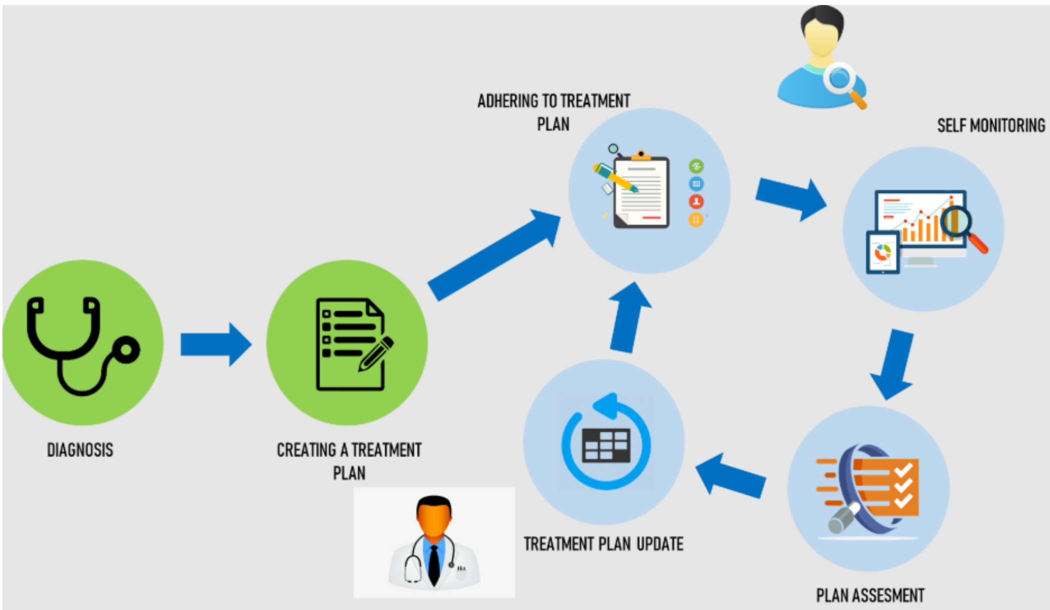

Fig 7 . 1 : AI and Chronic Disease Management.

7.1.2. Role of AI in Health Care

Incorporating artificial intelligence (AI) into the healthcare industry is expected to lead to revolutionary changes. A growing number of AI applications, such as machine learning, data virtualization, and data analytics, present opportunities for healthcare providers to enhance or augment their diagnostic skills and processes, often referred to as augmented intelligence. AI also offers the potential to streamline workflows and administrative challenges faced by healthcare providers and support patients in managing chronic care. The focus on a proactive approach to healthcare, which is supported by a series of studies using AI to analyze multimodal data, including medical imaging and demographic risk factors, demonstrates the potential for technologies to develop personalized medicine. Given the vast number of scientific publications and clinical trials, it is easy to comprehend both the potential that AI brings to the healthcare sector and the significance that the transition of AI-based methodology from proofs of concept to everyday medical practice represents.

Traditional medical research and practice use outcome-driven methods, or "reverse engineering" approaches, to identify and validate preventative strategies or therapeutics for a specific ailment. There is growing awareness that utilizing the advances in data and information technology, adaptive algorithms, and predictions can be applied to foster a practice that uses data-driven methodologies for medical informatics and more precise diagnosing and treatment of disorders. Specific conditions can be predicted or even classified based on a series of enzyme, protein, peptide, or chemical markers, or image-based methods through the application of AI and ML techniques to big datasets. Data-driven predictions, in turn, could direct proactive, personalized, and precise therapeutic strategies, a shift from classical reactive care, which has traditionally been governed by experts' opinions in medicine.

7.2. Challenges in Chronic Disease Management

Chronic diseases (CD) generally take a long time to develop and progress, and become irreversible. It has become more and more common for multiple CDs to appear in the same patient at the same time, which is referred to as comorbidities. There is often an overlap or interaction present among the diseases that require a change in treatment, adjusting the plan for each of them. While self-management is an integral part of managing CD, treating such complex and comorbid patient cases is too difficult and risky for a patient to do on their own. Unfortunately, changes often need to be made in the medications, food, and physical activity and be consistent between diseases to obtain effective and beneficial health outcomes. Non-adherence rates for CD range from 24% to 100%, averaging 56.8%. This widespread challenge makes it very hard to determine the effects of any treatment plan when evidence is often cobbled together from populations that have not been so hard to select and engage. Throughout the world, continuity in working and involvement of care providers to create consistent and synergistic treatment plans is a challenge. There is often moderate or expert-level disagreement in major clinical guidelines. Further, training on these interventions is not similarly strong in all countries. Patients are the only persons who are present in all encounters with care and are the only ones who can provide consistent data. So patient engagement and education are essential to all integrated care models.

In the past ten years, e-health and health cards have been identified as potential solutions to addressing these challenges, but have not managed to stay at the forefront of health innovation. They require access. Their adoption and use are not equally facilitated for everyone, and disparities in access to healthcare exist. Consequently, a challenge facing chronic heart disease (CHD) management and predictive analytics is improving the level of consumer engagement and adherence to suggested prevention and treatment plans. The study and development of these issues have given rise to two extensive bodies of literature, namely clinical psychology and social marketing for adherence and engagement. Adherence to chronic disease treatment plans is influenced by a variety of factors including physical factors such as exhaustion and mental resilience, socio-behavioral variables such as everyday-life practicality, and mental and emotional health (Danda, 2023). System and environmental factors may include access to a healthcare solution or social intervention, social stigma, denial of a diagnosis, or the reaction and feelings of significant others such as family and friends or influential figures in the lives of those they serve. There is a significant body of research aimed at improving adherence and engagement in people with chronic conditions and the development of new tools and systems to support individuals in the management of chronic health issues. However, although various strategies have been utilized and evaluated to optimize consumer engagement and adherence to CD treatment plans, the success of these strategies has been limited due to the difficulty in calculating health literacy, selecting the most appropriate strategy for each consumer, and keeping consumer engagement and adherence during the long length of time needed to manage and control chronic disease. There is a large body of knowledge that concentrates on socio-behavioral and psychological theories and models of adherence that could be relevant in the development of any tool or system to support consumers or clinicians in the chronic disease management process. However, just like the literature on clinical guidelines and training, not all of these theories can be generalized across all diseases, and their generalization to CD, which are diseases of chronic ill health, is even more controversial. As a result, the need for personalized tools to improve the quality of chronic care provision persists.

7.2.1. Adherence to Treatment Plans

Not following a treatment plan is relatively common across all types of chronic diseases. This could be due to patients not accepting the idea of having or potentially having illnesses, or they have subjective negative expectancy toward the treatment, or they do not see the health benefits right away to consider the treatment immediately sensible, or they have social and environmental factors that facilitate non-adherence, or they cannot access the treatment because other costs prevent it. It is important to understand some of the barriers that may be more common, especially the last two, from the patient's perspective. Whether we are considering adherence rates alone, the factors persistently associated with them, or the separate factors associated with adherence at different follow-up points, a consistent picture emerges.

Adherence is low overall, and many potentially remediable factors, especially patient-related factors, are associated with lower levels of adherence. In general, and unsurprisingly, non-adherence to prescribed regimens is associated with decreased health outcomes. Non-compliant patients mostly end up needing emergency inpatient or outpatient care for chronic diseases and have a higher risk of experiencing disease-related complications. The associated healthcare costs amount to about $200 billion per year with an estimated 100,000 patient deaths. Patients require ongoing support once they have started with treatment beyond the traditional adjustment visits. There is evidence to support the increased effectiveness of reminders in ensuring adherence to complex health regimens in general. Advice given by health professionals could also have an impact on the degree of adherence. Educational interventions in chronic disease can also have an additive effect on patients' understanding and attitude toward their health care. Finally, the patient's degree of trust and comfort with their health provider can have a substantial impact on whether patients will continue to be compliant with their therapy or not.

7.2.2. Patient Engagement and Education

Effective patient engagement and education are considered imperative elements for improving chronic disease management. When patients are informed about their health conditions and treatment options, they can make conscious and active decisions and are also more likely to adhere to suggested treatments and lifestyle modification strategies. Patients may need to learn new knowledge and develop new skills to manage their health conditions. Additionally, it is critical to ensure that the conveyed health information is well understood and access barriers are addressed. There are several ways to enhance patient education, such as using digital tools and platforms, printed or multimedia resources, expert lectures or panel discussions, patient forums, community group activities, and resources within community venues or local resources. It is well debated that 'one size does not fit all,' and the need for culturally competent health messages, delivered through culturally appropriate channels cannot be overstated. Due to the magnitude of the task, evidence-based mechanisms to reduce implementation gaps in this area need to be promoted by healthcare systems. An important step that supports advancing care is patient-provider communication, which must be respectful of the patient's needs. Trust and assurance in the clinician's ability are important and can facilitate a positive therapeutic relationship.

Research indicates that care delivery is often influenced by varying physician attitudes regarding patient engagement and activation, with perceived patient willingness to actively participate in their care being of utmost importance. Psychological barriers can also obstruct shared decision-making. Patients were concerned about the negative impact of questioning a physician's opinion on the quality of their care and their relationship (Syed, 2019).

The physician's commitment to care for the patient, using available knowledge and resources and professional neutrality, helps the patient to be open and actively contribute to decision-making. The patient is thus actively involved in making medical decisions, which reflect their needs and preferences, and the clinician advises the patient accordingly. This relationship is important, especially in chronic or life-limiting diseases, where shared decision-making may also need to take into account different people. Evidence suggests that engaging patients in their healthcare decisions can lead to improved health outcomes, better quality of life, increased adherence to medical regimens, lifestyle modifications, and decreased demands for healthcare services. Patient involvement has also demonstrated an ability to increase care efficiency and challenge decisions to enhance the effectiveness of the healthcare system.

Equation 1 : Predictive Modeling for Disease Progression:

$$\hat{y}_t = f(x_t, \theta)$$

$\hat{y}_t$: Predicted disease state at time t,

x_t: Patient-specific features at time t (e.g., lab results, vital signs),

θ: Model parameters,

f: Prediction function learned by the AI model.

7.3. Benefits of AI in Chronic Disease Management

AI has the potential to greatly facilitate early detection of exacerbation of chronic conditions through the automatic analysis of patient-generated data and prediction of impending worsening. AI can predict which patients are at high risk of readmission based on clinical, disease-specific, and social determinants of health. It also has the potential to reduce readmission by monitoring patients in real-time and alerting appropriate care managers so that they may intervene early, either coaching patients on self-management, removing social barriers, or even initiating therapy to avoid the need for hospitalization. Several studies have shown that artificial intelligence can analyze electronic medical records and adapt a clinical decision support system that recommends personalized treatment plans for individual patients.

Another area within chronic disease management that AI can revolutionize is generating personalized treatment recommendations based on patient-level data that includes information about the patient, the clinical condition, therapeutic options, and predicted outcomes with each therapy. These systems can generate clinical trial-like data that has clear parameters for efficacy, side effects, and ease of use, while at the same time being customizable to the profile of the individual patient. The combination of AI that delivers precision care and the ability of technology to deliver care at scale can not only improve patient outcomes but also reduce the cost of healthcare. AI models can show lower total inpatient, outpatient, and pharmacy costs for the prediction group compared to other risk classification tools.

AI can also be leveraged to improve patient experience by helping health systems deliver precise resources that improve patient outcomes. Evidence shows that when patients are engaged and they can be confident about the treatment they are receiving, their outcomes tend to improve. Decision support tools that explore patients' preferences and provide information can be a way to enhance patient compliance with care plans and treatments. Early detection helps patients with chronic diseases receive timely treatment to achieve better diagnosis and prognosis. It can thus lead to lowering the expense of hospitalization and operational and clinical processes and hence provide high-quality and cost-effective healthcare. In chronic diseases, such as COPD, in which there is a lack of healthcare support for the patients, periodic monitoring and targeting the patient even when they are at home provide another dimension to healthcare (Syed et al., 2020).

7.3.1. Early Detection and Prevention

3.1 Early Detection and Prevention of Diseases Chronic diseases are often slow processes of body deterioration that ultimately lead to debilitating conditions and large reductions in patient quality of life. AI can benefit by proactively identifying the early signs of such conditions before they become irreversible. Recent advances in machine learning have made it possible to learn from large datasets of historical patient records and identify patterns and risk factors for such conditions. As a result, early indicators and predictors of potential health degradations can now be identified. Preventative strategies can then promote early diagnosis and warning symptoms, thus facilitating interventions before the real onset of the disease. In the long term, early intervention and better use of medication can result in a reduction in overall healthcare costs associated with long-term, late-stage disease management. In addition, and perhaps more importantly, it will considerably enhance the patient’s quality of life. The major potential application area of AI is screening programs. Medical screening programs generally comprise technologies to identify the early and late stages of a disease. Diseases particularly caught in the early stage have a higher rate of being cured. However, in several chronic illnesses in which diseases are slow processes, several diagnoses are caught either in the intermediate stage or the end stage because the manifestations are recognized as symptoms in the late stages of the disease. AI has major potential to accurately identify early symptoms of a variety of diseases and can become an effective tool to help doctors timely diagnose health deterioration, ultimately leading to an overall healthier population and, most importantly, significant lifestyle and infrastructural changes. Such preventive care paradigms are expected to significantly impact policy development in healthcare management and public health, shifting from curative and management measures to preventive policy measures. This chapter also looks into how AI technologies can be used hand in hand with mobile-based applications and wearables that patients will likely use, and evaluate the data of health monitoring with the use of AI in outpatient management systems. Case Studies: In existing healthcare systems, several interventions have monitored the clinical assessments of individuals at risk of behavioral disorders. It has been shown that it could lead to early treatment that alters the mechanism of the mental health disorders that are expected to occur. There are three experiments in the preceding fields: (1) A therapy program for those with subclinical signs of psychosis was introduced in grossly different patient populations. The intention during therapy assessment would be evaluated. In the two experiments, the computerized tool described all or several high-risk individuals who underwent status assessments, which were not predictive. The global growth of such a tool is a prerequisite for the therapy experiment globally because evidence is necessary for a culture in which interventions for persons at high risk are implemented.

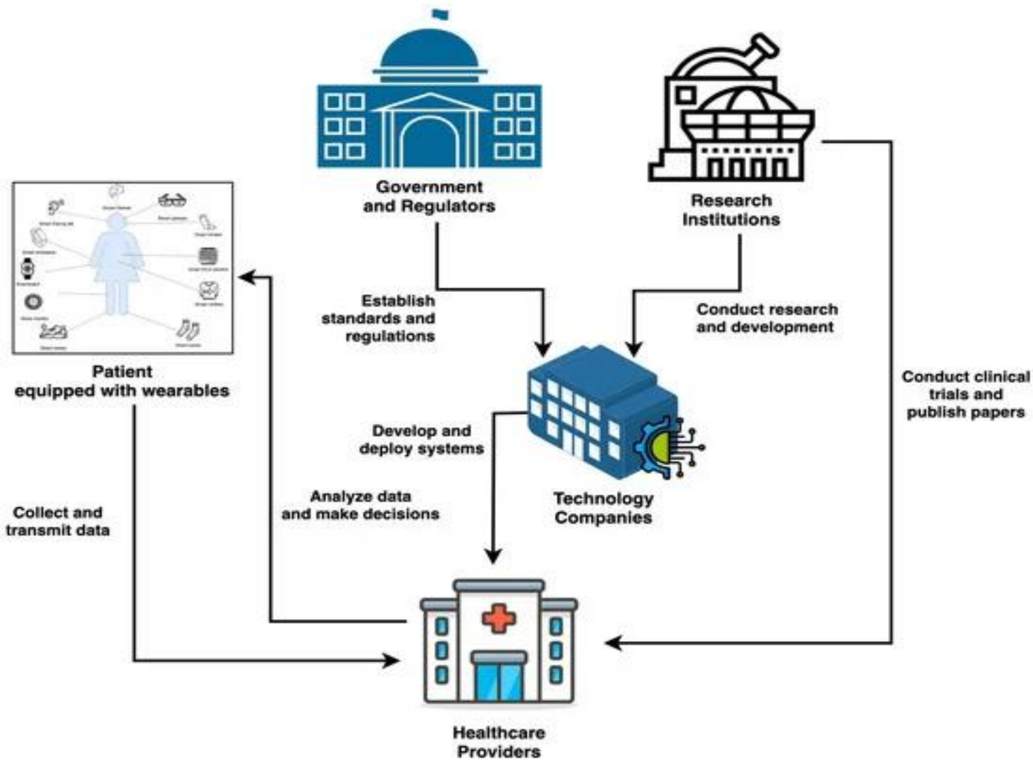

Fig 7 . 2 : AI for Early Detection of Chronic Diseases and the Spread of Infectious Diseases.

7.3.2. Personalized Treatment Plans

Personalized Treatment Plans Realizing the potential of AI in chronic disease management, new technologies have been designed to develop personalized treatment plans incorporating predictive models with information specific to the patients. For instance, the uses of AI have been extended to create personalized intelligent diabetes management applications. Treatment plans generated by these models will provide interventions tailored to individuals, thereby enabling the patient to comply efficiently by minimizing the number of medical interventions. Adaptation driven by real-time data feedback is an added advantage in personalized medicine. The ability to anticipate an individual patient's response is also particularly beneficial in chronic diseases, where effective treatment regimens can be a potential criterion for improving adherence and preventing patients from starting treatment that may not work for them. This results in minimal trial and error, which affects both the cost and resources incurred. Although the use of intelligent models for personalized treatment is a promising field with several success cases, false positives should be a concern. This means that we cannot anticipate who is likely to develop the disease. The ultimate problem resulting from the predicted behaviors is launching new questions, including whether it may indicate potential biostatistical issues. Furthermore, the use of personalized, proactive care will increase the amount of data that patients allow to be shared to achieve the desired service. Therefore, effective measures are essential to comply with ethical considerations aimed at data security and privacy issues. Currently, much emphasis is placed on chronic diseases that impose an economic burden on society and may contribute to overall public health. AI has played a vital role in providing potentially lifesaving individual care. Many studies have already been conducted in this area. One organization introduced a personalized health assessment tool to detect asthma in advanced years and reduce the cost of acute care by promoting self-care and avoidance. They point out that the tool was unable to yield accurate data, thus making it difficult to use. The advancement of the tools by implementing a user-friendly approach will aid in preventing these problems, hence promoting healthier lives. AI has also been utilized to diagnose cancer and kidney issues. More than 250 additional chatbots have been integrated with the artificial intelligence solution to detect and prescribe health care from home (Tulasi et al., 2022).

7.4. Case Studies and Applications

Some systems and applications explicitly focus on chronic disease management. In this subsection, various case studies across different areas are provided. While most of the innovations presented in chronic disease management have not been evaluated through empirical research, the clinical effectiveness of AI applications supporting chronic care in some areas is reflected in some applications of AI to management. Several examples are discussed explicitly. A system is being developed using a design science approach for diabetes mellitus management. Key features of this system include data annotation, multi-omics data integration, and predictive modeling including patient self-management behavior. Several health and care applications that co-create viewers have been involved with are described. A protocol to develop an AI technology that uses patient data to identify three-year survival in advanced cancer is proposed. AI work in progress to support frailty in a public prevention program is described.

Progress and lessons from a mixed-methods approach to scoping potential applications of AI in three cancer care pathways are demonstrated: early and late diagnosis; treatment selection and therapy monitoring; and supportive care, encompassing patient lifestyle and self-management. The paper includes a review of systematic reviews and research papers, interviews with experts in AI, oncology, and related fields, and a workshop with participants from the same group. Further work will result in broader insights for the cancer community and national policymakers. Some studies reported theoretical and prototype AI-assisted decision support tools for diabetes management, while in others, they were in use but not accessible for our study. The fully integrated system for psychological, social, and occupational functioning support is mentioned.

7.4.1. Diabetes Management Systems

Historically, blood glucose levels were monitored through finger pricking and self-monitoring. Over the years, interest in continuous glucose monitoring has surged. CGM involves the use of a tiny sensor inserted under the skin that measures glucose levels every few minutes. This data can be analyzed to detect patterns in a patient's blood glucose levels over time. This data technology has played a significant role in the diabetes management process. Several companies in the wireless health industry have built AI systems that establish predictive and preventive medicine ecosystems. One such company has developed a system that uses patients' blood sugar levels and lifestyle factors to anticipate hypoglycemia based on predictive analytics systems. This solution provides real-time predictive insights, supported by AI machine learning based on actual measurements of patients' glucose levels from a continuous glucose monitoring system, which monitors blood sugar levels in real-time (Venkata et al., 2022).

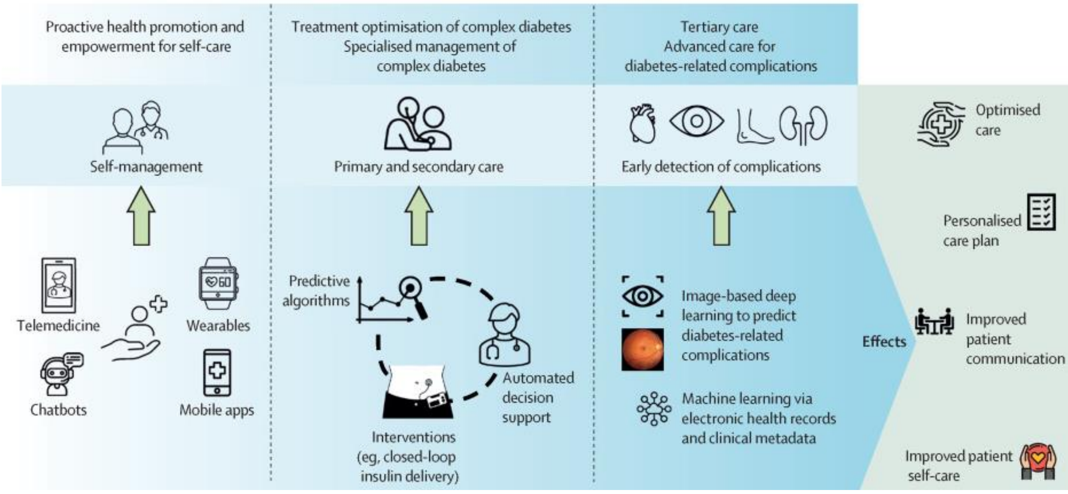

Fig 7 . 3 : Artificial intelligence for diabetes care.

In a study, a 41.18% reduction in HbA1c was observed among people who used the system. An SEM analysis further demonstrated the association between self-management and decreases in HbA1c, which ultimately leads to improving glycemic control. The 'insulin bolus advisor counseling', which collaborates with clinicians and people with diabetes, is an example of an AI-powered approach being used to improve the patient's medication adherence. On top of improved patient compliance, a retrospective study points out a 38% reduction in A1c among people who used the system. Predictive analytics systems are forecast to revolutionize the healthcare industry in the years to come. Not to mention, these monitoring solutions have provided a strong effect of AI transformation in chronic disease management, namely in the area of predictive analytics.

7.4.2. Cancer Care Decision Support

Developing decision-support tools to aid healthcare providers in cancer care is another popular research direction for AI in healthcare. Here, we concentrate on those decision support systems that aid care providers, predominantly oncologists, in making treatment decisions by providing patient-tailored evidence-based advice. A major area of application for these models is the generation of evidence-based or research-based treatment recommendations tailored to the patient based on their profile.

The main focus of these systems is to assist clinicians in making treatment decisions that are tailored to the patient's specific conditions and individual characteristics and are based on robust evidence. The value of utilizing AI techniques is indeed in their ability to swiftly examine, compare, and contrast millions of possibilities under different permutations of patient populations, interventions, or other key variables. One of the core advantages of leveraging machine (and deep) learning methods in this direction is the improvement of risk stratification and prognostic insights based on patient profiles. This approach allows us to delve deep into individuals' unique characteristics and facilitate a more personalized level of care (Pandugula et al., 2024).

For example, several studies and projects focusing on AI and oncological care in particular have shown the positive outcomes of utilizing AI models in treatment planning and patient outcomes. Machine learning-based diagnostic and treatment prediction models have been applied across a range of different cancer types to support sufferers from various angles and stages of the disease. In most treatment support tool cases, experts or practitioners are expected to supervise and review the systems and are primarily responsible for utilizing the recommendations for patient care. Since physicians are still responsible for validating AI system support tool recommendations, AI-based treatment tools introducing themselves without interventional confirmation are indeed possibilities. Shortly, healthcare providers might be forced by contemporary medical progress to put a larger emphasis on coping with the workload ethics of accepting the AI support tool predictions over their capacity to fully describe in-depth the scores of relevant covariates. Moreover, in the context of incurable or advanced disease, AI support tools may recommend various provisional options; prolonging life or declining potentially severe treatment, for instance. In these cases, patients' desire for participation in decision-making and information related to the upsides and downsides of declining treatment is a further aspect worth contemplating. Ethical discussions should also turn to the security and incorporation of medical information and patient views to consider a more secure approach, particularly if these insights can hinder an individual's residence or travel freedom. With several clinical centers, the project has so far successfully recruited and verified several hundred patients' informed consent. AI-based strategies or resources have yet to become an important part of management involving healthcare providers and patients. Because they expect that creativity will help to provide exceptional functionality, the hope is that these methods can fundamentally enhance the clinical paradigm for medical individuals. If patients refuse to share these data in scientific trials because of protection, secrecy, or antagonism towards clinical trials, we do not believe they can contribute to outcome bonuses. The most important system we use to facilitate this would be the integration of patients with AI-based interventions. What varies, though, is the incentive between individual clinics, because all initiatives involve the integration of a new diagnostic and treatment prescription AI tool. Ethical concern is necessary to make decisions about the incorporation of this medical knowledge.

7.5. Ethical Considerations

Despite the significant potential of AI to improve chronic disease management and care in an era of increasing multi-morbidity, there are ethical issues related to the integration of AI in this context. First, the use of AI algorithms in chronic disease management puts patient privacy at risk, especially when data gathered from smartphones and wearables are involved. The resulting adverse consequences might go as far as restricting future health or life insurance opportunities. Trust between patients and healthcare professionals is vital, and such trust may diminish if treatments are measured and assessed by algorithms over which clinicians do not fully have control. To preserve this trust, algorithms have to be transparent, interpretable, and contestable. A recent systematic review identified several challenges related to ethical AI in chronic disease management, including bias, proprietary technology, privacy, and security.

Bias in AI arises as a result of biased historical data used in the training phase of the algorithms. Due to the complexity of multi-morbid patients and their care processes, the optimization of predictive performance may inadvertently lead to a situation in which certain underrepresented groups may be disadvantaged by receiving less or sub-optimal care, thereby leading to an inequitable distribution of health outcomes. Several guidelines are available that aim to prevent discrimination and inequitable distribution of rights and duties in a society that employs digital technologies. These guidelines call for the development of "ethically responsible" technologies, which are designed to "promote health equity and fairness," to ensure that "the distribution of benefits and disadvantages, access and control of the primary social goods is fair and requires the means to enable everyone to achieve their full human potential." There are also ethical guidelines for the responsible development of AI, which call for fairness and avoidance of discrimination by AI developers. Central to this is a right of access, i.e., the ability for all stakeholders to understand the core reasons for any decision made by an AI. In healthcare, as elsewhere, transparency is a vital component of fairness. In the absence of such tools, this may lead to a situation where patients become wary of their health data, separating them from their clinician or disengaging from the care AI supports, with potentially harmful consequences for their health. Treatments and patient journeys are shaped by AI systems through clinical decision support, the maintenance and enhancement of value, and the identification of those at risk of developing or suffering from a long-term condition. At this point, healthcare professionals' judgments and experiences, along with the uncertainties and cultural and social considerations that come with it, may be bypassed by AI algorithms. A truly ethical approach to the use of AI in health requires complex stretching beyond the development of new algorithms. Importantly, healthcare professionals need training so they can make ethical decisions regarding the use of the data their patients generate in their care, and further work is needed on a system-wide level to ensure that the benefits generated by AI are fairly distributed. In the integration of AI in the management of chronic diseases, we must ensure that we balance the need for technological advancement with the need to retain ethical standards (Kalisetty et al., 2023).

7.5.1. Privacy and Data Security

Keeping in mind the growing need for sophisticated data processing and analysis in the field of AI, especially for clinical data, the risks of sensitive patient data being either inappropriately accessed or breached are significantly increased. The consequences of such actions can be disastrous and could lead to potential treatment interruptions, and humankind cannot afford such mistakes. The need for data protection is thus the highest. Several challenging aspects need to be taken into consideration when processing or analyzing clinical data using AI environments. The very first and most important aspect is how to protect the privacy of the data and the patient. In general, the identification of human behavior, characteristics, and habits may lead to profiling and, at the problem level, to discrimination, persecution, or commercial targeting. Such improper exploitation might lead to reduced trust in AI solutions, challenging the uptake of AI in chronic disease management. Thus, a fundamental challenge is how to balance the need for private data collection against privacy and personal data protection legislation and ethics. An initial task needs to address if there is a genuine need for specific-person data, or if the study can work with and utilize metadata or completely anonymized data that has had specific persons removed but conserves its value for training AI algorithms and outcomes of model predictions. Data used in AI systems must, by law, either be fully anonymized or de-identified data. What one must consider is the balance between data anonymization and the value in analyzing and making inferences from such data. Too much data caveating or dilution limits the training and prediction capacity of AI models. Laws such as the Data Protection Act regulation in healthcare data require stringent methods for de-identification of data; techniques and methodologies exist, although without intensive utility on the impact of AI analysis on judicious privacy dilution and the sensitivity of such techniques. Another approach for using personal data for AI analysis without too much caveating can be through very explicit and detailed patient-signed informed consent explicitly stating that their data may be used for AI training and predictive analysis. This is not standard and not widely practiced. The second issue is data integrity. AI systems can be trained and tested on mission-critical data. Supply of such systems with inaccurate or purposely manipulated data might lead to adverse decisions with harmful consequences. To create trust in such systems, a robust monitoring as well as auditing system must be put in place. The process of continuous monitoring and ethics review, that is, assuring that ethical and legal guidelines are adhered to and applied, is an important issue and incentive to set up the groundwork to assure that initial and ongoing informed consent by genuine research subjects is in place and serves as essential guidance for good governance and utilization of data. This becomes even more relevant when comparing previously collected data with current and future collected data, thus assuring the privacy and safety of citizens due to anonymized data which still retains its utility on a broader scale. It is important to know that several legal and ethical issues need to be adhered to when collecting, reviewing, updating, and auditing AI systems because they are required to process data about humans to function.

7.5.2. Equity in Access to AI Technologies

There is no doubt that the unaffordability of some new technologies puts certain people at a disadvantage, and AI software is no exception. Even though AI can significantly expand the scope of a less expensive workforce, access to care depends not only on technology but on many other secondary and tertiary factors as well. As of now, plenty of people do not have access to services and care providers; some consumers face challenges when they access these services, and potential societal respondents are excluded from these services. The breaking news is that certain low-resource communities are systematically excluded from the conditions in light of AI. Their struggles are shaped by and anchored to structural inequities and technological exclusions—both digital and algorithmic.

The deployment of advanced AI in routine healthcare without adequate attention to inequities may amplify the already profound disparity known to exist in patient care. Society's already profound healthcare disparities are magnified by the "digital divide," defined as the difference between those who have access to AI and data resources in healthcare and those who do not. AI should benefit all patients, but the reality is a stark one. Patients living in low-income communities, which often consist of populations of color, are less likely to experience equal benefits from technological investment. The adoption of AI in healthcare should aim to eliminate, rather than exacerbate, existing bias within the allocation and distribution of resources to reduce healthcare disparities. Policymakers, legislators, and healthcare organizations should consider how AI innovations can be used to address healthcare disparities. Numerous initiatives have been introduced to mitigate the risk that AI will create social asymmetries in research and drug creation. AI has also developed consciousness-enhancement efforts to scale AI use to enhance the use of AI by healthcare services. These are funded by organizations working with stakeholders and making AI health verification available to different healthcare classes. This is important because it guarantees that AI systems can be accessed by end-users in theory for research and improvement. The same industry has proposed an AI-developed awareness campaign detailing the need for awareness of AI equipment. These solutions were designed to benefit services, stakeholders, and researchers in the evolution and testing of innovative methods that use healthcare AI. However, both systems have yet to be investigated.

Certain guidelines exist concerning the development of essential AI awareness in the preparation of medical professionals and health organizations. One of the most critical aspects of an integrated healthcare awareness AI readiness curriculum is long-term treatment. Informing healthcare professionals might further advance the process of accepting AI in healthcare. An approach is required to address the problem of AI discrimination in long-term patient care. Recommendations from healthcare workers, policymakers, health systems, payers, and AI companies should be included in efforts to eliminate inequalities, shift power, and develop AI solutions in healthcare to favor all groups, regardless of various forms of discrimination. Stakeholders that may be influenced by AI discrimination provide incisive novel viewpoints concerning the future of healthcare AI research and development. The inequality of AI has a significant influence on the conception of AI research and development, as highlighted by their proposals.

Equation 2 : Treatment Optimization:

$$\theta^* = \arg\min_{\theta} \frac{1}{n} \sum_{i=1}^{n} L(f(x_i, \theta), y_i)$$

θ^*: Optimal treatment parameters,

n: Number of patients,

L: Loss function (e.g., mean squared error, cross-entropy),

y_i: True treatment outcome for patient i.

7.6. Conclusion

Unmanaged, chronic diseases present widespread challenges that affect patient outcomes and healthcare efficiencies. AI promises to support the healthcare system, ameliorating some of these challenges. In particular, the development of prediction AI and AI-supported technology will offer the potential for healthcare pathways to be altered based on proactive healthcare delivery. Broadly, rapid advances and the utility of AI illustrate a need for professionals to engage in a continued dialogue with the public, patients, the AI community, and policymakers. Furthermore, tools that are intended to engage patients in a shared decision-making paradigm communicate a need for cross-disciplinary collaboration between health professionals and AI developers. Numerous ethical, individual, and systemic challenges must be navigated to ensure the effective and efficient integration of AI technologies.

In the future, the increasing complexity and additional layers to the predictive models developed may lead to greater model performance. Data could be mined directly from EHR to incorporate additional components such as social determinants of health. Further, engagement, use, and output of predictive AI tools should be subject to ongoing evaluation to ensure effective translation of intended developments. Alternatively, in combination, future research could involve the evaluation of ML integration into these workflows. These strategies will support the ideal user of predictive AI tools, particularly ensuring adequate training and support are offered for clinicians to use and to discuss results with patients. Importantly, patients should be involved in the development and education of such tools. Finally, to individually manage chronic diseases, this model requires shared and patient-centered intervention, thus ensuring that precision healthcare stakeholders, including patients, can operationalize algorithms that are tailored to their care needs (Sondinti et al., 2023).

In conclusion, AI promises to transform chronic disease management, embedding proactive, precision approaches into care pathways. The potential economic, individual, and societal gains of operationalizing such patient support methods are vast.

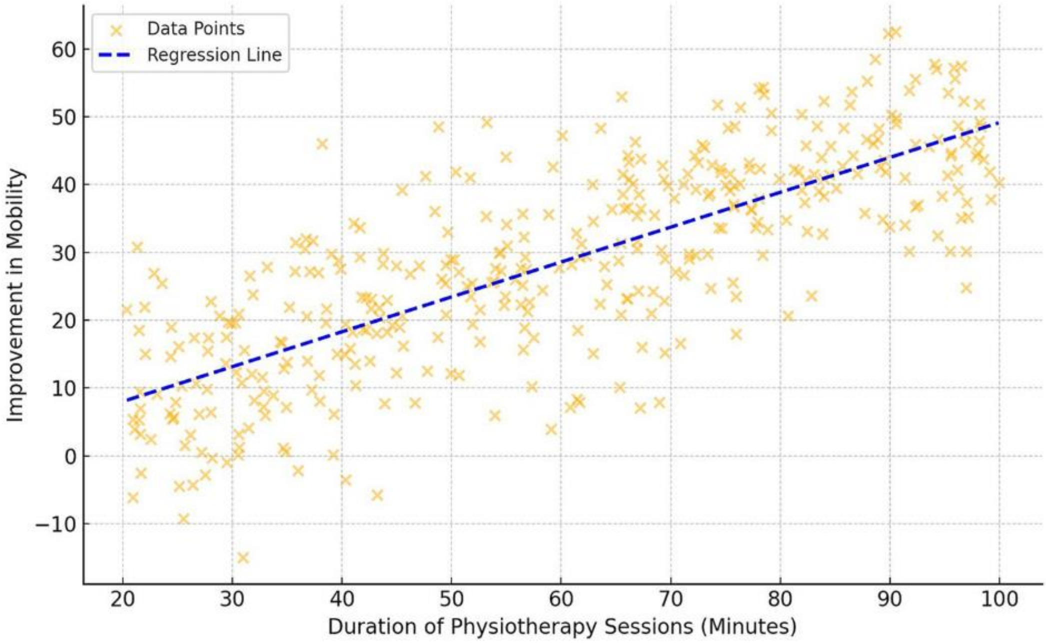

Fig 7 . 4 : Health Outcomes in Older Adults with Chronic Diseases

7.6.1. Future Directions

Advances in AI technology, machine learning, and predictive modeling will continue to shape the healthcare of the future. The rise of more efficient systems will need to be tempered with developments that allow for better integration, cross-communication with EHRs and shared databases, and research into automated assistance with prescription and treatment plans. Continuing research will focus on extending the predictive capabilities of the HARLT system using integrative disease surveillance, investigating methods for weight-related feature imputation in different datasets, and building a probabilistic causal model to link multiple negative states in the prediction of patient health. Knowledge gaps within this emerging field of AI and chronic disease management remain, particularly in developing integrative models of care and increasing the accuracy of predictions made with incomplete data. The design will need refining through direct input from end users, and rheumatoid arthritis patients. User behavior in AI systems will also play a role in the accuracy of predictions: a transdisciplinary approach is required for developing accurate and inclusive models of user behavior, specifically identifying the key determinants of good and non-compliant behavior.

AI will continue to evolve in computing power and predictive analytics due to increasing technological capabilities. Hardware used for AI will continue to shrink in size and resources required to run heavy simulations decrease. These physical changes to AI hardware are predicted to make the technology more accessible to the general public, an artificial intelligence revolution that has already demonstrated uptake throughout health and medicine and indeed, given medicine's deep pockets, is likely to be where new advances roll out fastest. The increase in research funding for AI and its incorporation of predictive algorithms and machine learning in healthcare in conjunction with EHRs makes chronic disease management the much-needed focus of technology. Despite current gaps, customized AI-led solutions for chronic disease management are at the forefront of technological innovation, addressing current need states in chronic disease management and care that are not met by current practice. In these ways of shaping the future, AI will enable proactive, predictive, and personalized management pathways for chronic disease patients that will alleviate the stresses of illness and offer a higher quality of life for the future. Ensuring barriers to the uptake of AI are met demonstrates the transparent and patient-centered approach to improving public trust factors and enhancing service uptake of the AI system. A point of view where AI and technology systems work in harmony for the benefit of patients and healthcare providers is a point that can only be achieved with collaboration across a multidisciplinary workforce including health professionals and patients.

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