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Chapter 6: Predictive healthcare: Using artificial intelligence to foresee and prevent future illnesses

6.1 Introduction

Today the world experiences an unprecedented patient data explosion. Especially in the clinical domain. Over the course of years, a hospital generates data that is more than the data generated by any of the other sectors regarding the patient. It results in a cumbersome, sensitive and unstructured data form. In such a situation, it sets excellent scope for developing artificial intelligence for leveraging predictive analytics and classifying diseases with high accuracy. World experts are harnessing the power of artificial intelligence and predictive analytics to prevent illnesses before they start. This approach is called predictive healthcare and it is radically transforming the way doctors forecast and treat a wide range of health conditions. This essay will explore predictive healthcare systems that utilize artificial intelligence and big data to foresee and avoid future health problems. Unravelling the ways these high-tech systems predict diseases before they even manifest will make it clear how integrating AI in health systems is the need of the hour. It is essential to realize the falsity of ignoring predictive healthcare and it will also marvel at how technological progress can reveal key to longevity and productivity. Dive deep into the essay and anticipate deciphering about a subject no hospital wants you to know (Annapareddy & Sudha Rani, 2024; Challa et al., 2024; Kannan, 2025). The essay aims to narrate the applications of predictive analytics systems that support scientific evidence and patient-centred outcomes. The paper will highlight the ways that AI delivers positive health effects that were not feasible with conventional strategies. The government and hospital sectors are obliged to be pressed into leveraging full potential to predict diseases before a person attains them through enhanced advanced algorithms and predictive analytics. The essay is intended for people who need to acknowledge the choice to predict their disease, but insist on knowing the potent consequences prior to thinking of doing so. Few weeks earlier there was an unawares meeting with retirement patients in a hospital to learn they were

suffering from a disease which they did not get affected with yet. With a huge assortment of data science tools, an AI system had carefully predicted the possibility of their disease, well ahead of them experiencing any symptoms. What caught attention, even more, were the testimonials that these AI-generated predictions were surprisingly accurate.

Fig 6.1: AI Predictive Analytics in Healthcare

6.2. The Evolution of Healthcare

From an early age, healthcare has been focused on prevention, diagnosis, and treatment, regardless of geographic location. What began in prehistoric times as using natural materials to treat illnesses developed into a deep field where knowledge and technology were combined to provide complex treatment options.. Apart from diagnostics, there have also been ongoing improvements in operations. In the past, a patient's decisions on their treatment plan were left entirely to healthcare professionals, but this logic has changed today. Instead of traditional methodologies, a more multidisciplinary approach is followed more often. Another example of how improvements are coming is the changing of old protocols. One of the oldest known protocols is that of the UK's National Institute for Health and Clinical Excellence. Offering advice on the use of new drugs and treatments, it soon became the gold

standard. As time went on, new protocols, similar to that of NICE, began to be established worldwide, and they began to be followed seriously. However, with the advancement of new methodologies, it is now much more difficult to make a decision using these methods alone, and a combination with sophisticated computer models becomes necessary. With the ongoing changes in health and healthcare systems along with the rapid increase in technology and the amount of healthcare data generation, traditional care processes and treatment models may be inadequate nowadays. In parallel with these rapid changes, predictive healthcare, which uses artificial intelligence algorithms to anticipate diseases and other health problems before or during their occurrence, is starting to be widely discussed.With the rapid advancement of technology and the growing complexity of healthcare, traditional models of care and treatment are increasingly being challenged. Predictive healthcare, powered by artificial intelligence (AI), has emerged as a transformative approach that goes beyond simple diagnosis and treatment. AI algorithms are now being used to predict potential diseases before they occur, analyzing vast amounts of healthcare data to identify patterns and trends that would be difficult for humans to spot. This shift from reactive to proactive care not only helps in early intervention but also allows for more personalized treatment plans, making healthcare more efficient and tailored to individual needs. As AI continues to evolve, its integration with traditional methodologies and protocols promises to revolutionize the way healthcare systems function, improving outcomes and reducing costs. (Kannan, 2025; Sriram, 2023)

6.3. Understanding Predictive Healthcare

The term predictive healthcare typically implies the use of predictive analytics to anticipate and mitigate health-related issues before their actual occurrence. Predictive analytics, which is the method of analyzing historical and existing data for the sake of predicting future health issues, is capable of anticipating health problems before the onset of symptoms by identifying the early warning signs. Subsequently, actions can be taken to prevent or mitigate the issue before it becomes more serious. This makes predictive analytics very proactive. The concept of predictive healthcare falls within the scope of traditional predictive analytics. However, in healthcare, it has a specific goal of the anticipation and prevention of upcoming health issues to adequately intervene when care is actually needed so outcomes for the patients are improved. Moreover, healthcare systems have a more intricate structure and integrate many applications which are either automatic or involve the human factor in the decision-making process. It is therefore the methodology and the use cases that are defined in this context. Finally, the use of predictive models on healthcare data brings about many new ethical issues, as the medical sector handles sensitive data and people’s life and health depend on the systems in place. Using the term predictive healthcare rather than

predictive medicine underlines the whole complexity of the field. Predictive healthcare involves the use of predictive models to enhance patient care by appropriately intervening ahead of time when care is needed. The proactive component of such systems is underlined. Ethical limitations are also integrated into use and design considerations. Five key points need to be understood to consider adequately the challenges and opportunities predictive healthcare brings to the current healthcare systems. The first is the foreknowledge which is the ability to predict future events. Preventing, interpreting, or avoiding risks in a timely manner is possible when they can be predicted. These anticipations can in turn save people time, energy, money, and even their good health.

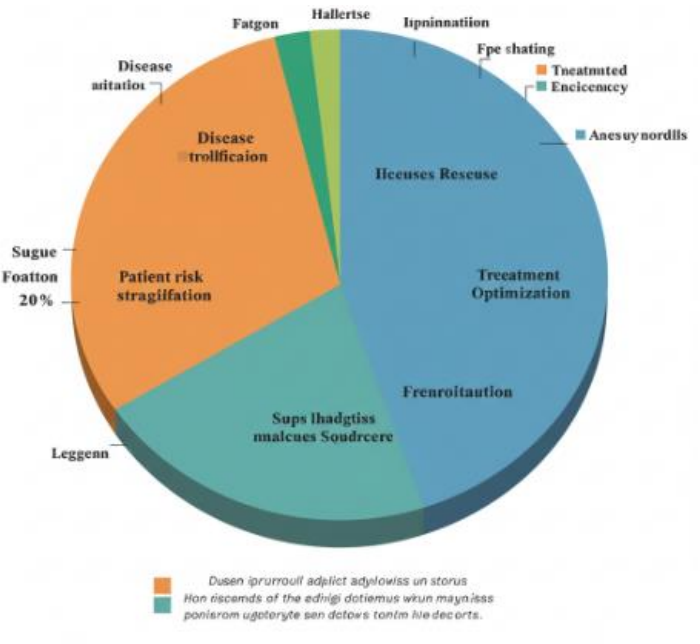

Fig 6.2: Predictive Analytics in Healthcare

6.3.1. Definition and Scope

Predictive healthcare is the nature of foreseeing illnesses in advance at the onset. It analyzes and mines the healthcare data for developing the healthcare predictions. Predictive healthcare is being developed with diverse data analytics and healthcare practices, combined with a variety of patient engaging strategies. The development of predictive healthcare integrates the practice of data analytics for data cleaning, data analysis, and predictive model development of healthcare data. Analyses, big data processing, data mining technologies, and effective knowledge of data analytics become the key components of the development of predictive healthcare. Meanwhile, a wide variety of applications involving prediction in clinical healthcare are also developed. Those predictions are, however, usually achieved through the medical data

stored in the cloud. Hence, the healthcare analysis of the cloud repository has become another key practice in clinical application. Moreover, the healthcare industry is now rapidly migrating to the cloud platform, and hence it reshapes the manufacturing practice infrastructure. To support the application of predictive healthcare an architectural framework is proposed. The time variant process allows the decision maker to timely interpret a large number of predictions for enhancing the healthcare decision making.

The importance of the world of health to society as a whole has not gone unnoticed, with prevention being pursued as a priority as the costs and life expectancy of the population. In recent years, patients have become more involved in their healthcare, seeking ever-greater access to healthcare data. However, the complexities are present and still represent a limitation to the modeling process of predictive analytics. Choosing the right model can have a dramatic impact on the result, particularly when non-statisticians are reviewing the valid vision of prediction outputs, analysis, and data interpretation. Thus, healthcare providers should be aware of the models used to interpret the crucial data.

6.4. Artificial Intelligence in Healthcare

As the complexities of diagnoses, treatment options, and patient monitoring have continued to grow, so has the medical field's need to utilize artificial intelligence to its fullest potential. The emergence of artificial intelligence technologies makes it increasingly feasible for the healthcare sector to profit from them, turning the spotlight on predictive solutions. AI predictive healthcare solutions allow medical staff to quickly diagnose a person’s conditions, treat and monitor the healing process. They liberate specialists from rows of office work, leaving them the important part of making diagnoses and treatment decisions. Luminaries are created on the basis of these data, analyzing machine-learning models. Patients no longer need to waste their time waiting for the analysis results and sondage facilities for advice for some diseases; they can receive the above-described service at home or in pharmacies on a paid basis.

Aimed at providing a comprehensive insight into that field, the presented review subsequently moves on to explore AI applications in healthcare business, their potential to augment human authors’ expertise in medicine, and the foreseeable difficulties and ethical caveats, as well as regulatory bureaucracy. The paradigm of professionals working together with predictive solutions in diagnosing patients is put forward to highlight the notion of AI’s complementary role and the necessity of human intervention. Indeed, the imputation of AI technologies into the existing framework of healthcare business proves to be a challenging issue. Predictive systems have to comply with a wide range of legal requirements prior to usage, including patient’s data

protection, transparent criteria for decision-making, validation, and a provision of informativeness for clientele. Nevertheless, AI devices are predicted to prevail in diagnostic tasks, leaving the therapeutic part to medical staff. It is envisioned that the leading form of collaboration between professionals and algorithms would involve human decision making on the basis of AI-generated recommendation.

6.4.1. Overview of AI Technologies

Predictive Healthcare has gained increasing attention in the last decade. Patients, practitioners, and researchers more actively try to foresee and thus, prevent the development of maladies. Growing computational power, AI algorithms, and new types of data all demonstrate great potential to shape the future of medicine. It is like a futuristic movie where health problems and various abnormalities are detected, and treatment plans are personalized even before any clinical sign becomes apparent.

The efficacy and the wide use of these technologies in healthcare will have direct effects on various actors. As existing patterns in the already very large, but rapidly increasing, health-related data will be identified, the accuracy of diagnoses is improved. Methodologies for improved treatment plans based on individual patient parameters are also increasing. AI predictive healthcare would also directly affect the society by decreasing the economic and emotional burden.

AI predictive analytics essentially constitutes strategies used to foresee impending implications involving the use of data and statistical algorithms. Several AI methods have been in existence for a long time, such as neural networks, while others, such as some variants of Levon and deep learning, are of a recent origin. Additionally, there are several techniques like graph mining, tensor decomposition, and variational Bayes inference, which are not widely used in healthcare due to their complexity.

Many AI algorithms use very complex computations and thus require considerable computational capabilities, which ought to be in parallel with the rapid increase of digital healthcare data. The effort on electronic health records (EHR) alone has made these data reach petabytes worldwide. Indeed, there is a large necessity for new AI algorithms that can operate on the most influential features of the data within an acceptable time on very large datasets. On the other hand, certain works have demonstrated that so-called simple methods, such as multivariate linear regression can provide results comparable to those of more complex alternatives in high-dimensions, in terms of the predictive performance.

AI technologies have clearly reached a tipping point within the healthcare sector. Policy makers agree that they will revolutionize the operational aspect of hospitals, just as today, at the beginning of ‘20s, ML is widely adopted in industry. Efforts are aiming at adopting them in a way that suits the needs of various stakeholders, minimizing

potential psychological side-effects on staff performance. It is important that, when establishing the conditions for the utilization of AI algorithms, hospital managers will involve healthcare personnel already accustomed to AI technologies. This can open the way to the development of future technologies and potential impacts regarding the operational aspects of healthcare institutions. That said, the accurate reproduction of such a future is challenging.

6.5. Data Sources for Predictive Analytics

Data is being accumulated faster than ever before. Because of this, the volume of data continues to grow at a staggering rate, outpacing the capacity of traditional data analytics. However not all data is suitable or valuable for the detection of trends or patterns. A considerable amount of data is necessary for the good working of predictive analytics. Nevertheless, it must also be of high quality in achieving the best predictions. The most suitable data sets provide sufficient information about: what is to be predicted (the outcome), which types of attributes influence the outcome (predictors), and the type of influence they have (predictive accuracy). In healthcare there are several sources of data only waiting to be analysed therewith. It can come from: commercially available clinical databases; data from Wearable Technology, which could be integrated directly with other state-of-the-art AI systems for optimized health monitoring and maintenance; open-source databases with population health statistics, as well as demographics from different areas; and other data from diverse formats, such as time series records and image processing on radiographs and blood smears, in addition to free-flow unstructured text notes that are commonly used in routine diagnosis and disease monitoring. However, the use of unstructured data raises the need for text mining techniques to convert it into structured formats like Word Bags, which can be further translated into elements of the prediction model. The first challenge arising from this promise of data is to standardize it all as far as possible. The second challenge is maintaining interoperability among different systems and environments to ensure a common language for the AI systems involved. This standardization and interoperability are the background to the development of data governance policies, ensuring ethical and compliant practices on the use of data. Nevertheless, the implementation of those policies often proves to be a major drawback due to confidentiality and competitiveness issues. A further recommendation is to use real-time field data and prevent it from first passing through any front-end provider, however, and also as a way to minimize sources of error and lag-time unnecessarily added before inputting the data into the predictive model.

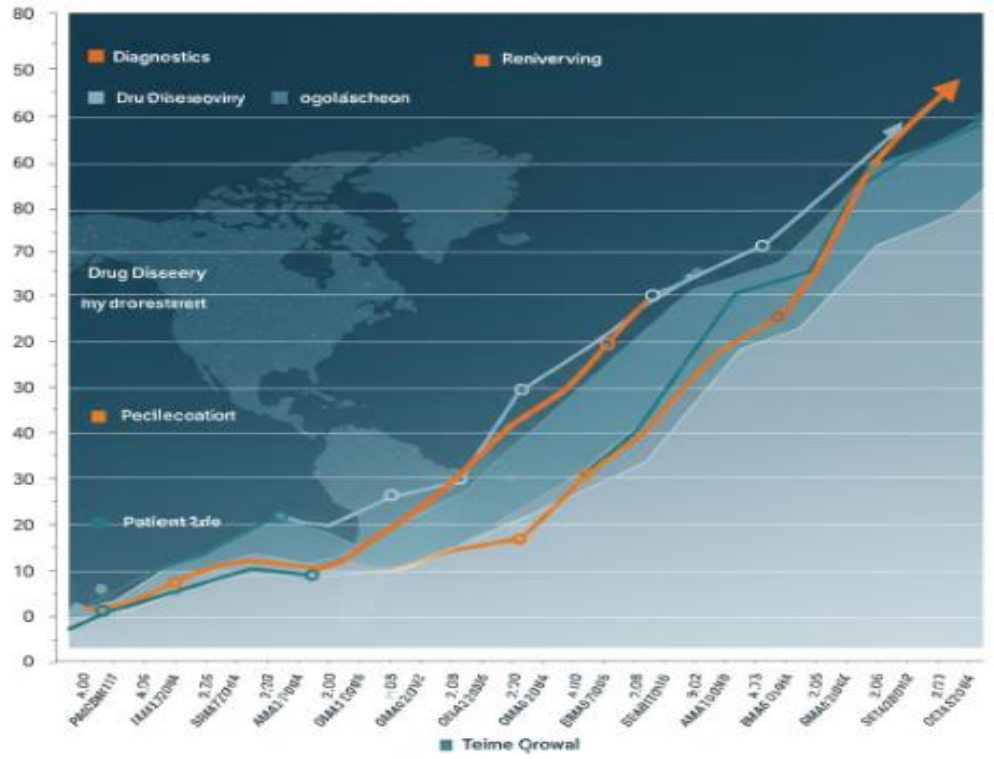

Fig : AI in Healthcare Statistics

6.5.1. Electronic Health Records

The prolific and varied sources of patient data are increasingly the backbone of clinical practices and medical research. The adoption of electronic health records (EHRs) has revolutionized how vast amounts of patient data are documented, stored, and accessed by clinicians. In addition to the conventional structured data of demographics, diagnoses, and medication prescriptions, EHRs often include primary signs and diagnoses, laboratory results, imaging reports, note transcripts, and flowsheets. Presenting a comprehensive and up-to-date view of a patient's health status and the services provided for a particular health condition, EHRs allow clinicians to compare and analyze the effectiveness of different treatment plans. EHRs also enable health researchers to investigate potential causes, mechanisms, and treatments of health conditions by observing the patterns and trends of medical services utilization. Moreover, the upcoming wearable devices and internet-of-things sensors can continuously monitor the patient's health status and behaviors during their daily lives.

The potential applications of EHR data to further patient healthcare include patient insights and continuous health monitoring. Rich and comprehensive EHR data can be analyzed as time series data to identify the baseline and anomalous patterns of a patient's health status or services utilization. These patterns may indicate the co-

occurrences of the health outcomes or adverse events of medical services. Furthermore, EHR data can be mined to build the scoring systems or predictive models to evaluate the likelihood of a patient's future health status or services utilization. These analyses can be conducted by the traditional statistical modeling, machine learning methods, or the recent developed deep learning and natural language processing techniques to extract the valuable structured knowledge or patterns from the unstructured EHR data. Notably, AI-driven predictive analytics can have the potential to leverage the vast and varied EHR data for clinical research, leading to the evidence to improve the health policies and patient outcomes [1]. Future technical innovations in the EHR system could increase the automatic data linkage or facilitate the comprehensive data sharing and thus promote the EHR evaluation research in patient health and public health. The advantages and benefits of EHR-based predictive analytic methodologies are discussed as well as their promises for improving patient outcomes. Meanwhile, the limitations, challenges, biases, and potential solutions of applying EHR data, including missing, noisy, biased data, data privacy, and data security issues, are analyzed. Lastly, a critical view of EHR evaluation research is presented, emphasizing research conduct, analysis, and result reporting to reduce false findings.

6.6. AI Algorithms in Predictive Healthcare

With the rapid growth and demands of Artificial Intelligence (AI) applications in healthcare, many AI algorithms were developed and designed specifically for healthcare access. A wide range of prediction type problems (classification, regression, forecasting, etc.) regarding healthcare access use these algorithms on a daily basis. In using AI algorithms in predicting healthcare practices, fundamental principles are the development and selection of the right algorithms. To achieve this, the consideration of healthcare objectives and the problem being faced are fundamental because the characteristics distinguish healthcare access problems from conventional prediction problems. In knowing these characteristics, the important aspects of healthcare access are highlighted, and the suitable algorithms recommended. Prediction type problems are one of the most common problems conducted in healthcare access when either a diagnosis of a patient or forecasting future medical operations will be made. To have this kind of prediction, diverse prediction algorithms can be applied. The prediction can be made using statistical methods by assuming a distribution of the future events and forecasting them. Machine learning methods inherently conduct prediction problems. The prediction is directed to a set of features (or dependent variables) by learning the historical correlations between the features (input variables) and the target features (dependent variables). Besides statistical and machine learning prediction models, for healthcare access some AI models can also predict the occurrence of a particular future event due to the behavior of future patients, such as the prediction of

patient outpatient department access to predict future visits before making any actual access. All the mentioned models of prediction algorithms can be implemented in a variety of prediction type healthcare access problems.

6.6.1. Supervised Learning Techniques

AI predictive analytics is seen influencing healthcare establishment in the near future. Predictive healthcare is a prospective area. It is important to foretell individuals at risk of developing killer diseases in time to take actions. Furthermore, a full understanding of building a predictive healthcare model may benefit many readers. Supervised learning algorithms being introduced first since they are the most widely used in predictive healthcare.

Supervised learning, as the name suggests, involves algorithms that learn from labeled data sets. Each input object in the data set is associated with a true label that is to be learned. Using the labeled data as the guidance, a supervised learning algorithm learns a model that maps the input objects to the desired output. This learned model can later be used to make predictions on new, unseen examples. There is a wide range of methods for supervised learning. The most common ones are regression and classification. In regression, the model tries to predict a continuous function output. While in classification, the model further classifies. Because an illness can manifest in various ways, from few mild complaints to severe clinical symptoms many years apart, supervised learning can be an effective mechanism to improve predictive accuracy and use the accuracy estimates with confidence for the onset of specific health outcomes. Some effective methodologies are shown, especially on how to implement them in predictive healthcare better. This is followed by discussions on preparing datasets, feature selection, model training, and validation testing. At the end, a few successful cases are given that best illustrate how the tools and resources discussed above are applied and what potentials can be further explored.

6.7. Conclusion

In the emerging world of predictive healthcare, illnesses can be forecasted and preemptively addressed. Technologies such as machine learning models and predictive analytics are increasingly being used to collect, analyse, and evaluate variables that are known to effect chronic diseases, such as personal behaviors, environment, and therapy compliance, in order to predict health outcomes. Through pairing this information with healthcare big data in real-time, AI can foresee an individual’s risk of becoming unwell. It can be further used to predict the likelihood of them being hospitalized—the length of their stay, the need for a ventilator, and the patient’s probability of survival.

The development of such tools is transformative. Healthcare will no longer be solely reactive, focusing on treating illnesses as they arise. Instead, a more proactive approach, of foreseeing and preventing afflictions, will be embraced. This is, especially, relevant for chronic diseases such as Chronic Obstructive Pulmonary Disease (COPD), which, although can be managed effectively, cannot be completely cured. COPD will become the third leading factor of global death by 2050. Big data's predictive capacity, and the advancements in artificial intelligence, will allow for the greater efficacy of guidelines, and a quantitative basis for policy making, enabling better allocation of healthcare resources. But it is not without complications. At present, there exist a plethora of obstacles to implementation—technical, political, ethical—and healthcare professionals must take the time to understand, and collaborate to engage with these solutions.

6.7.1. Future Trends

The development and availability of artificial intelligence (AI) and machine learning technologies have been expanding over the past decade. Due to the rise and emergence of these technologies, they are expected to soon be a significant facet of predictive healthcare. AI and machine learning technologies have remodeled and reshaped not only conventional industries but also several segments of the sectors concerning policy-making processes. It is widely agreed that AI and machine learning applications have the potential to form a critical basis to the analytics and automation levels needed for social and economic transformation, global health systems and service reform. A recent report explains how AI and machine learning can dramatically change economies and societies across a plethora of sectors, including the health and socio-political sectors. In 2015, the U.N. determined a program named the Sustainable Development Goals (SDGs) that manages international development responsibilities. Such aims have aimed to develop lucrative, healthy communities where financial services are also open. By attaining these goals, a consideration is required to accumulate, coordinate and share medical, social, economic and drug data. Common forecasting devices such as smart diagnostics, wearables and internet-of-things applications could super-foster these recently mentioned development programs. By 2030, customizable health platforms foresee a significant impact on SDG achievements, adjusting to different global locations or economic statuses. A move from common forecasting devices to customized health platforms is underway and is primarily patient-associated. This prompts the sector to concentrate on preventative care, giving guidance for lifestyle, regular check-ups and accident prevention. Several investments will be put forth into the AI and machine learning applications associated with big data transmitted by wearables and portable phones. AI and machine learning technologies also have the potential to facilitate access to good medicine for all by 2030, targeting applications of computer-aided diagnosis in observing real-time future

states of the health market. There is potential for IT advances in transport predictions, creating high-quality SVoIA systems which could augment experiences in offices and medical care. It is additionally foreseen that AI and machine learning advances work on recognition software for social assets, safeguarding historical legacies and enabling unwanted medical care and clean water provisions. AI and machine learning applications are perceived to essentially change the planning and the organization of health. A smart health platform developed by 2030 is expected to be operationally advanced, utilizing present-day assets by employing AI, machine learning and big data analytics, specifically with treatment and diagnostics. The platform is assumed to exhibit dynamic engagements and centralized hubs to simplify remote medical intervention paths, offering early warnings for abrupt health hitches. Ambitions lie in the instinctive interface design, knowledge representation and enlarged device and sensor networks, hosting model health hubs handling symptoms, treatments and medical records of patients. With the development of anticipatory medicine, this AI and machine learning platform coupled with health technologies seeks to detect and anticipate upcoming diseases.

Based on the global improvements of economics and technology, recently investigated health informatics reveal an increasing trend in the development of AI and machine learning technology adoption for a variety of health assessments like disease analysis, long-term health analysis, medication streaming examination and treatment prognosis. Above interpretations propose unique viewpoints in presenting the multidimensional aspects of AI healthcare viewpoints on overall incorporation evaluations, industrial forecasting, worldwide usage and general social nexus. Nonetheless, there are numerous substantial considerations to think about in continuing to develop and broaden an AI-based healthcare study and solution. Prior evaluations and future outlooks of AI-fielded healthcare options disproportionately manipulate extensive and worldwide data samples from the advancement and the medical safety profile of AI.

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