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The Future of Healthcare: How Precision Medicine is changing The Game - A Systematic Review

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ABSTRACT
Precision medicine is a transformative approach to healthcare that leverages genomic and lifestyle data to tailor treatments to individual patients. This approach is revolutionizing healthcare in several ways. Firstly, it enables personalized treatment strategies, ensuring that patients receive therapies best suited to their unique genetic makeup and lifestyle. Secondly, it improves diagnostic accuracy by identifying specific genetic mutations responsible diseases. Thirdly, it facilitates prevention and early detection of diseases by understanding a patient's genetic risk factors, thereby enabling proactive healthcare measures. Fourthly, it aids in the development of new drugs by targeting specific genetic factors contributing to diseases. Lastly, despite the high initial costs of genetic testing, precision medicine could prove more cost-effective by eliminating the trial-and-error approach to treatment, thereby reducing unnecessary healthcare expenditure. In conclusion, precision medicine is ushering in a new era of healthcare that is more personalized, effective, and efficient, promising a brighter future for both healthcare providers and patients.
Keywords: Personalized Treatment, Improved Diagnosis, Prevention and Early Detection, Drug Development, Cost-Effective Treatment.

INTRODUCTION

A novel approach to health and sickness that examines individual patient data is precision medicine, which is also called precision health. Considerations such as the severity of the condition, medical diagnosis, and even environmental and lifestyle variables are all part of

this. Since it originates from several sources, this compiled data is known as multi-modal data. The exponential rise in the quantity of individual patient medical information has had a profound impact on the development of precision medicine. Modern scientific advancements in areas such as genetics, medicine, and others are primarily to blame. Many data has to be understood and analyzed since there are so many various sorts of testing. Fortunately, advancements in the field of computing have also allowed us to store and analyze this data far more effectively than in the past. Combining the two is how computer science is enabling precision medicine to make use of healthcare's massive data sets. The word "precision medicine" has evolved throughout the years, which contributes to the lack of clarity around its beginnings [1]. People are living longer and healthier lives because of precision medicine therapies for many critical ailments.

For instance, spinal muscular atrophy (SMA) type I was formerly fatal in newborns less than two years old, but gene therapy has made a difference. What a miracle for these kids and their families that they are able to live longer with fewer major health issues (Singh et al. 2017). However, transfusion medicine was an early adopter of a precision medicine strategy for the treatment of human illness. Blood donations were revolutionized when blood types were identified in the early 1900s. Less incompatible blood was an issue as we could now match recipients with donor types of blood [3][4][5].

Plenty has transpired in the field of precision medicine since then. Innovations in illness prevention, diagnosis, and treatment are reshaping the medical landscape. Precision medicine has garnered much encouragement from several groups due to its effectiveness. These organizations include authorities, study and medical financing bodies, and the public. The use of machine learning has the potential to revolutionize the field of precision medicine in the years to come, and this mini-review aims to demonstrate that potential. Genetics, big data, and cutting-edge ML methods will be my primary topics of discussion, along with the relevant legal and ethical questions [7].

LITERATURE REVIEW

A lot is happening in the field of precision medicine right now. The field of precision medicine has grown into an all-encompassing strategy that integrates different kinds of data to thoroughly comprehend health issues, illnesses, and treatment choices for persons. It is frequently characterized as the medical transformation started by advances in genomic sequencing and molecular genetics [8]. We shall call this strategy "precision medicine" and the effect it has on patient treatment "individualized care" throughout the article. As a result of advancements in precision medicine, doctors no longer have to rely on broad statistics to make diagnoses; instead, they may consider each patient's specific traits while making treatment plans. It opens up new opportunities by enabling doctors to provide individualized treatment to each patient [8].Early illness identification and more access to personalized therapies are two examples of the concrete advantages that have resulted from advances in precision medicine [9][10]. Data collecting and analytics instruments make it easier to tailor treatment to each individual. Investigators now have an once-in-a-lifetime chance to make sense of clinical and diagnostic information collected from the real world because of the convergence of genotyping with high rates and the broad use of electronic health records (EHRs). When integrated with EHR data, these findings strengthen the case for further therapies or lead to more accurate diagnosis of disease variants. Currently, genotype-guided treatment is one of precision medicine's most researched effects on healthcare. Decisions like the correct dose of drugs like warfarin are aided by genetic information, which is used by healthcare professionals [11]. Clinicians may use the recommendations released by the Clinical Pharmacogenetics Implementation Consortium to help them optimize pharmacological therapy according to genetic test findings. Targeted treatment programmes for patients with lung or breast cancer may also be informed by tumour genetic profiling [10].

When applied to health care, precision medicine has the potential to improve the accuracy of diagnosis, the timing of disease risk assessments, and the development of individualized treatment programmes that are both effective and safe.

There is a global trend towards building data archives to facilitate precision medicine; it is not limited to the U.S. The worldwide effect of shifting perspectives towards accuracy is shown by case studies from biobanks throughout the world, including the U.K. Biobank, BioBank Japan, and the Australian Genomics Health Alliance [12][13]. Testing, validating, and modifying treatment approaches still requires a lot of effort, even with the promising prospects of A.I. and precision healthcare. Adopting standardized formats for data (such as Fast Healthcare Interoperability Resources) is one problem that researchers encounter. Another is acquiring enough outstanding data with labels to train models. Finally, there are legislative, confidentiality, and intercultural factors that must be addressed [12][13].

METHODS

We searched Medline (Ovid), Embase (Excerpta Medica Database), WoS (SCI Science Citation Index), and PubMed (Ahead of print/First online) to examine the findings of science. In order to find relevant research, we used both regulated language (descriptors) and free language (genomic service, personalized medicine, health national programme, etc.). Recent research was our primary emphasis, and our search approach was adjusted to fit the language of each resource. The Supplemental information contains the comprehensive search methodologies. In addition, we looked through the listed papers' citations to do a secondary search. Further, we looked for reports from foreign health technology evaluation authorities in the EHR dataset. To find national health policy texts, plans, and laws, we also looked at institutions or governmental databases.

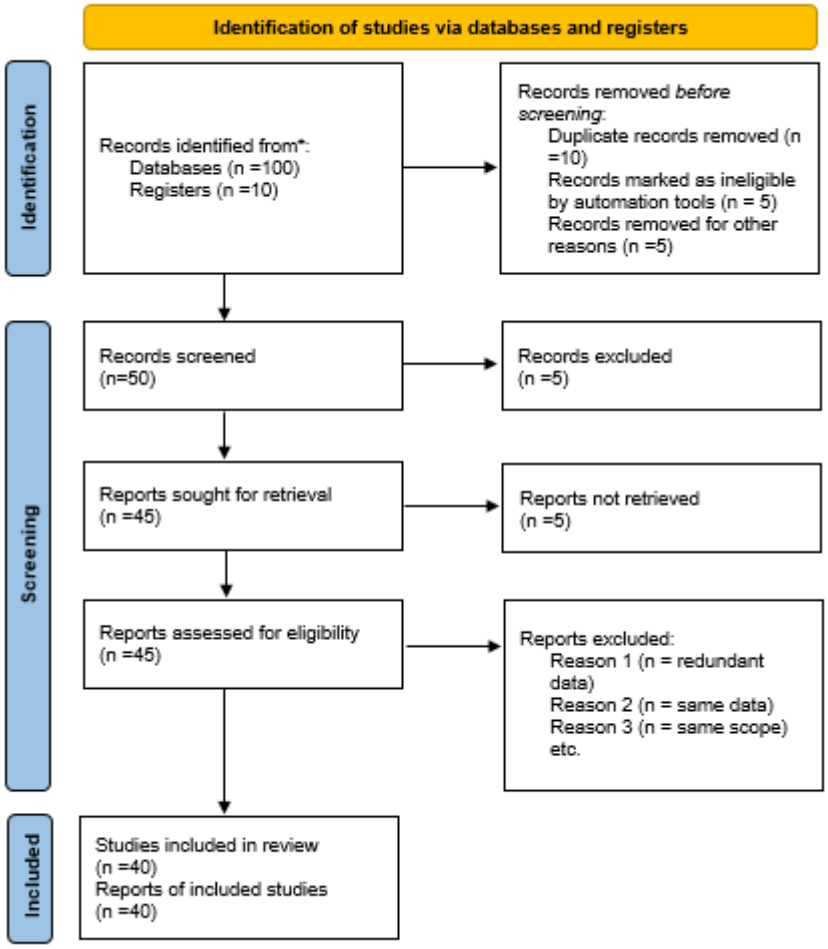

Figure 1: PRISMA flow chart for the studies conducted

RESULTS AND DISCUSSION

For identifying prospective targets for the development of novel medications, biobanks that are connected to electronic health records (EHR) have become indispensable tools. When taking into consideration the work that Dewey and colleagues did, they worked along with Regeneron Pharmaceuticals and accessed the exome sequencing information that was stored in the electronic health record (EHR) of 58,000 patients at Geisinger Health System. According to the findings of their investigation, there is a correlation between mutations in ANGPTL3 that cause a loss of function and the onset of coronary artery disease. They developed a monoclonal antibody to inhibit the protein, which indicates that there is potential for the illness to be prevented. This finding was the foundation for their work. Similarly, Ionis Pharmaceuticals demonstrated that antisense oligonucleotides that target ANGPTL3 could prevent human individuals from developing cardiovascular disease. While conducting studies in the field of pharmacogenomics, biobanks that are connected to electronic health records have been of critical use in determining the genetic variants, which have an impact on the efficacy, responsiveness, or tolerance of drugs, particularly those that are thought to affect metabolites. Projects such as eMERGE and Pharmacogenomics Research Network (eMERGE-PGx) discovered that a significant number of 5,000 clinical individuals possessed at least one actionable mutation in 82 pharmacogenes. This proportion was determined to be 96.2%. There are a number of complicated aspects, such as penetrance, expressivity, and mode of inheritance, that make it challenging to understand gene function via the use of electronic health record (EHR) analysis. Focusing on uncommon mutations with significant effects, such as loss-of-function (LOF) variations or protein-truncating variants (PTV), which are anticipated to have a considerable influence on gene expression, is one strategy that may be used to address these issues. In a study that was conducted not too long ago, Dewey and colleagues looked at a massive sample of people and discovered that, on average, every human being contains around 21 LOF mutations. The researchers found novel correlations between genes and characteristics, such as erythrocytosis, by analyzing electronic health record data that spanned about 14 years. In addition, they discovered that 3.5% of the population possesses clinically actionable variations in 76 genes and that 65% of these variants are related to disorders that have been reported in medical records. The researchers Abul-Husn et al. investigated the effect of previously identified harmful mutations in genes associated with familial hypercholesterolemia and discovered that genetic testing might be used to predict severe cardiovascular outcomes. In a similar vein, the sequencing of the lipoprotein lipase gene in the same group has shown clinical usefulness in the identification of hypertriglyceridemia. Furthermore, the sequencing data extracted from the biobank was shown to be reliable for detecting BRCA1/2 mutations that are associated with breast cancer. This demonstrates that biobanks that are primarily focused on research may also serve clinical objectives by increasing access to genetic testing. A further significant finding was made by Belbin et al., who found that variations in the COL27A1 gene are associated with an uncommon phenotype of short height. This phenotype has a more significant incidence (>2%) among people of Puerto Rican heritage than previously thought. This discovery emphasizes the significance of integrating members of underrepresented groups in databases used for scientific research in order to guarantee equal access [26].

The development of an entirely novel structure was accomplished by the execution of a systematic review by a group of specialists in this area and personalized medicine (PM). The objective of the framework above is to use both qualitative and quantitative methods in order to evaluate the degree of PM adoption in a variety of worldwide healthcare systems. Through the use of theme analysis and the approach of consensus, the team was able to identify crucial components that were required for using this framework. Their research question and

systematic review provide a thorough strategy for applying PM. This method takes into consideration the intricate relationships that are present within today's health information systems. They came up with a search for published material techniques that used an extensive strategy since they wanted to ensure that PM was appropriately implemented in healthcare systems. They designed a framework that allows for both quantitative and qualitative assessments of PM deployment across a variety of nations by making use of pre-existing structures, designs, or research as a foundation. As an additional benefit, this framework may serve as a guide for the design of PM applications as well as health policy measures. A framework of this kind has never before been developed and defined in relation to health systems, and this represents the first time that it has been done so. During the process of building the foundation, some of the studies that were taken into consideration included incomplete instruments for evaluating the adoption of PM in some organizational regions and applications. Agarwal et al. concentrate on analyzing PM incorporation in U.S. healthcare organizations [29][32], whereas Doyle et al. primarily focus on the organizational features of centres delivering PM [33]. An international financing of creativity model with a particular emphasis on South Korea was created by Lee et al. [34]. Another unique feature of this framework is that it was developed via a systematic review by a group of specialists from a variety of fields who are experienced in precision medicine (PM). This evaluation established domains for assessing the degree of PM adoption and the accessible items within them. All of the studies that were incorporated into the overview were written by people from a variety of nations, which indicates that the structure may have an opportunity to be applicable all over the globe. There is a strong emphasis placed on the significance of healthcare policies in the execution of PM, with domains concentrating on legislation and transformational tactics. The incorporation of PM into medical facilities is made more accessible by a health strategy that is properly integrated, which also ensures that the integration is done correctly and in a standardized manner to provide patients with utilization of PM. For project management (PM) to be successfully implemented, it is vital to promote both fundamental and translational studies. In this context, the structure emphasizes the need to encourage cooperation between medical care and laboratory studies [29].

With regard to the execution of PM, sufficient funds are necessary. The resources in question include facilities, electronic systems, and data administration. Both the accessibility of PM data in clinical settings and the enhancement of patient trust in the medical industry are dependent on the correct handling and safety of PM data. The actualization of PM needs to include the modification of organizational areas within healthcare organizations, with a particular emphasis on the consolidation of previously present sectors and the interpersonal connections that exist among them [29].

EHR-linked biobanks are helpful in determining whether the correlations among genetic polymorphisms and phenotypes that have been documented in the past are correct. Take, for instance, the illuminating study that Haggerty and colleagues conducted [35], in which they investigated the influence of database-annotated detrimental and probable detrimental modifications that are associated with arrhythmogenic right ventricular cardiomyopathy (ARVC). Through the examination of the exomes of 30,000 individuals, they found 18 individuals who have a variation that is thought to be responsible with ARVC. Unexpectedly, none of these people had any symptoms of arteriovenous varicosclerosis (ARVC), which is generally simple to identify with the use of an electrocardiogram. The majority of individuals who were thought to have detrimental abnormalities did not really display the characteristics that were anticipated, according to further analysis. The occurrence of arrhythmia-linked alterations in people's electronic health records was the subject of another significant research that was conducted by Van Driest and colleagues [36]. They discovered that individuals who had a large number of supposedly dangerous mutations did not have a substantially increased

likelihood of becoming diagnosed with any arrhythmia, nor did they exhibit any arrhythmia-related characteristics that were captured in their electronic health records [36].

Table1: Specific area of precision medicine and its description

Key Area	Description
Cancer Treatment	Targeted therapies like Herceptin[15][16] [17] [18] [19]and Gleevec[14][16][17]demonstrate the power of precision medicine in combating specific cancers.
Mental Health	Identifying genetic links to depression and anxiety [20][21][22]can pave the way for personalized treatments.
Infectious Diseases	Precision medicine can help tailor antibiotics to specific bacterial strains, reducing antibiotic resistance [23][24][25].

Table 2: Essential importance of precision medicine

Importance	Description
Customized Patient Care	Precision medicine allows doctors to select treatments based on a genetic understanding of the patient's disease. This can lead to more effective treatment plans, with certain drugs proving more effective for specific genetic profiles [27][28].
Improved Clinical Outcomes	Precision medicine testing and treatments generate additional sources of revenue for hospitals while simultaneously leading to improved clinical outcomes that will enhance patient satisfaction [30].
Data Integration	As precision medicine data becomes increasingly complex and available, health I.T. and EHRs must evolve to integrate, interpret, and deliver this data [29].

Policy Development	Healthcare stakeholders must enhance and address health I.T. data, health I.T. infrastructure, EHR integration, and policy development to achieve precision medicine [29].
Patient Empowerment	The use of patients' data could accelerate scientific discovery and progress toward precision medicine [31].

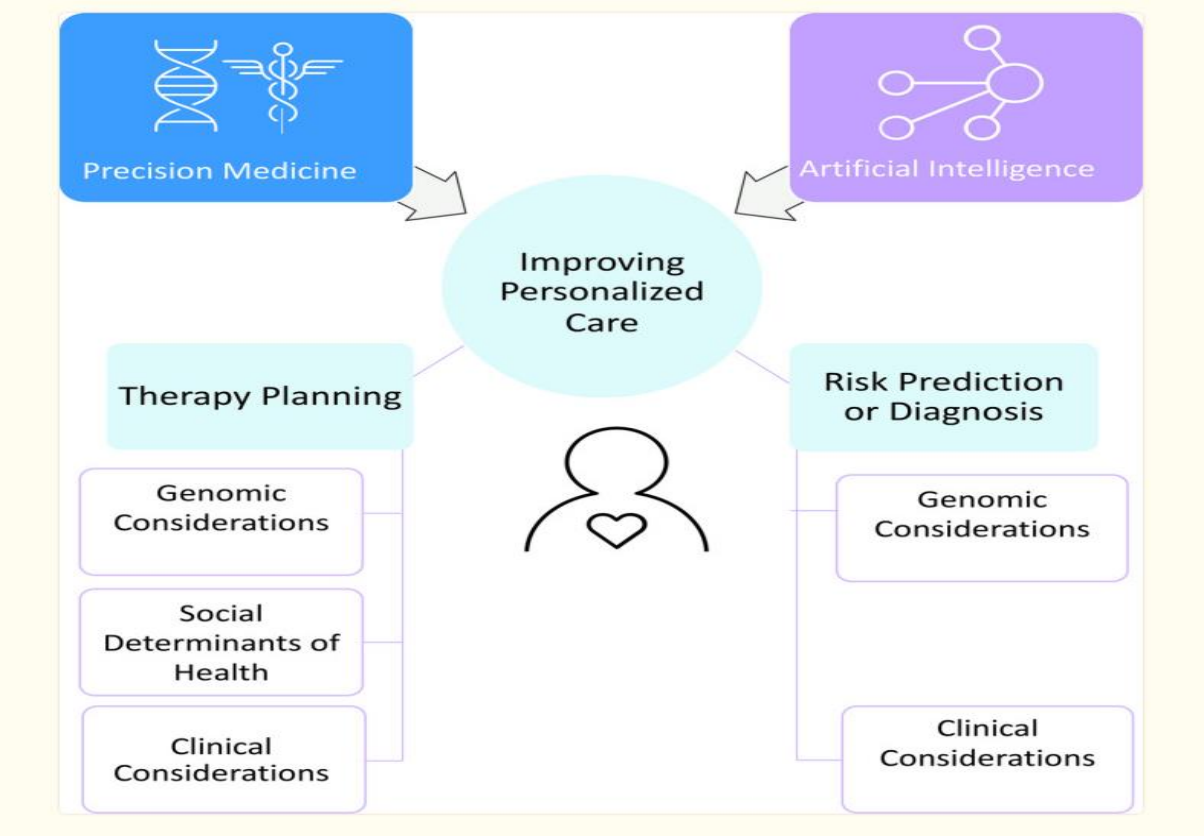

Figure2: Precision medicine applications in the healthcare industry and their relationships with the other factors [6]

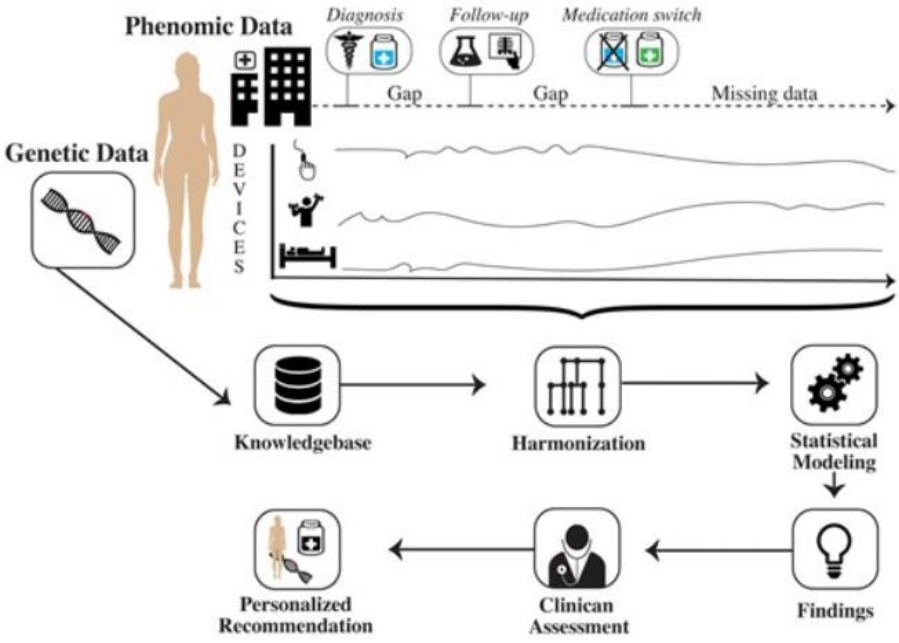

Figure 3: Workflow of precision medicine data process [26]

Problems encountered in precision medicine:

Issues of a serious legal, regulatory, and ethical nature are raised by the use of artificial intelligence in precision healthcare. In the first place, protecting the privacy of patients is of the utmost importance since machine learning models need large data sets in order to be trained effectively. Questions concerning patients' right to privacy are raised, however, when patient information is shared across different places. The use of distributed machine learning methods is one option that has been offered. In this approach, algorithms are trained locally on data at each location before going on to the next centre, which helps to maintain patient confidentiality [37].

On the other hand, additional study is required to guarantee the efficiency of such models that do not rely on centralized data. The opaque nature of conclusions made by machine learning algorithms is a further cause of concern, mainly when dealing with complicated data. In light of the fact that doctors may need help comprehending the conclusions that a model draws on patient treatment, this lack of comprehension presents both legal and ethical concerns. Initiatives are now being taken to improve comprehensibility, which is essential for the incorporation of artificial intelligence into medical decision-making. Despite this, there are still problems around culpability for mistakes that machine learning models produce. This is because the regulatory structures that are now in place need supervision from humans and accountability. In addition, ethical conundrums are posed by technical limits. Machine learning models are dependent on data for training, which may be biased or inadequate, which restricts their capacity to generalize across a variety of healthcare situations. Enhancing the amount of information used for training might be a solution to this problem; however, the sharing of data is hindered by legal and practical obstacles. As a consequence of this, regulatory bodies require machine learning tools to be used as supports rather than as independent decision-makers, highlighting the supporting function that these tools play in the clinical setting [37].

The possibility for bias within medical precision datasets, particularly with respect to genetic and genomic data, is another critical worry. This bias may be caused by patient selection, which results in the selection of patients. These biases not only have an impact on the accuracy and applicability of machine learning models that have been trained, but they also exacerbate economic and other forms of inequality as they lead to systemic discrimination

based on factors such as race, ability, gender, and an individual's socioeconomic situation [38]. Furthermore, owing to financial and logistical restrictions, the adoption of precision medicine is mainly restricted to industrialized nations. This means that people in poor and third-world countries are not able to reap the advantages of this kind of therapy [39]. In order to guarantee that the globe is treated fairly and to develop our study and treatment of health and illness on a global scale, efforts must be made to involve these diverse populations. Behavioural repercussions of precision medicine findings on people's illness preventive tactics are another concern that emerges in relation to the possible implications of these findings. If people find out that they have a hereditary predisposition to heart disease or obesity, do they think they would change their behaviour to accommodate this knowledge? Furthermore, these findings may identify people as "patients-in-waiting" who have not yet become sick but are at a high risk, which could give rise to uncertainty and worry for both the people in question and their relatives. Therefore, individuals who employ precision medicine in clinical settings need to keep in mind the specificities of every single patient and the conditions that are unique to them [40].

There has been a surge in the number of efforts made to integrate artificial intelligence in precision healthcare for tasks such as illness detection, risk prediction, and therapy response. On the other hand, more evidence is needed to indicate how A.I. might benefit healthcare. In addition to accuracy, dependability, safety, and ability to be generalized, these are other essential factors that will determine whether artificial intelligence technologies are successfully used in the real world. Problems such as prejudice in medical information may have an impact on the reliability and equity of artificial intelligence algorithms. It is possible, for instance, that biases in information might result in choices that are unfavourable for specific populations on the basis of age, gender, ethnicity, or economic status. The identification and reduction of bias in the information and models is of the utmost importance, and several methods, such as increasing the variety of data and making use of fairness measures, have been suggested. Socio-environmental variables also influence the effectiveness of A.I. models in healthcare contexts. According to the findings of research on diabetic retinopathy assessment, hospitals face difficulties as a result of a wide range of circumstances and processes, which disrupts both the picture quality and the processing speed. A crucial step before broad application is the validation of artificial intelligence models in healthcare settings and the collection of user input for advancement. The convergence of artificial intelligence and precision medicine raises essential questions about data privacy and security. In order to construct a safe environment for the storage and administration of data, emerging technologies, collaborative efforts, and regulatory frameworks are required. To solve many of the issues that are present in precision medicine, it is possible to train artificial intelligence approaches and validate models by utilizing massive datasets prior to connecting those models to sensitive information. The development of person-specific connectors to autonomous devices for providing personalized care is now being investigated using technology such as mobile applications and implants [41].

Future prospects:

In order to build software that is both successful and practical, it is essential to ensure that computer researchers and medical professionals work together effectively. Through the integration of ethical inclusiveness, knowledge in the creation of software, implementation research, and the values of interaction between humans and machines, a network of artificial intelligence professionals may construct an entire structure for the set-up and upkeep of A.I. systems. Additionally, cooperation across different medical environments is necessary for sharing and confirming the quality of data as well as the outputs of analyses, which is critical for the success of artificial intelligence in clinical practice. In order to ensure that healthcare workers get proper instruction and training, beginning with collegiate levels and ending with

continuous growth, it is essential to provide this information and instruction. Because of this, adequate adaption is ensured, patient care is improved, and any potential ethical or legal difficulties are reduced. For providing prospective workers with essential information and fostering greater awareness and use of artificial intelligence, medical institutions should include issues relevant to A.I. in their overall curriculum. A significant amount of appreciation has been found among radiologists' physicians for the incorporation of artificial intelligence (A.I.) instruction into medical school programmes. This highlights the significance of early involvement with A.I. ideas in the context of healthcare instruction [42].

CONCLUSION

In conclusion, the integration of electronic health record (EHR) data with biobanks has revolutionized biomedical research, enabling the identification of novel gene-disease associations and therapeutic targets. By leveraging large-scale genetic data and long-term health records, researchers have made significant strides in understanding the genetic basis of various diseases, predicting clinical outcomes, and advancing personalized medicine. Moreover, the utilization of EHR-linked biobanks has facilitated the inclusion of underrepresented minority populations in genomic studies, promoting diversity and equity in research outcomes. As technology continues to evolve, EHR-linked biobanks hold immense potential for further discoveries and advancements in healthcare, ultimately leading to improved diagnosis, treatment, and prevention strategies for a wide range of medical conditions.

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