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# ADVANCEMENTS IN PERSONALIZED MEDICINE: INTEGRATING GENOMIC DATA FOR TAILORED THERAPEUTIC APPROACHES

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***Abstract***

*The integration of genomic data into clinical practice has ushered in a transformative era for personalized medicine, allowing treatment strategies to be tailored based on an individual's genetic profile. This shift from generalized care to precision health has been driven by advancements in high-throughput sequencing technologies, gene-editing tools such as CRISPR-Cas9, and AI-enhanced analytical methods.This study explores the application of genomic technologies across major therapeutic domains, including oncology, cardiovascular diseases, rare genetic disorders, and infectious diseases. Methodologically, the research synthesizes data from large-scale genomic projects and incorporates computational models for risk prediction, variant analysis, and AI-guided therapeutic recommendations. A risk scoring formula was employed to quantify the clinical significance of genetic variants in disease prognosis and treatment planning.The results demonstrate substantial improvements in diagnostic precision and therapeutic efficacy. Specific mutations were successfully linked with targeted therapies in oncology, while pharmacogenomic profiling allowed for individualized drug dosing and minimized adverse reactions in cardiovascular treatments. The implementation of gene therapies in rare disorders showed promising clinical outcomes. Furthermore, the integration of AI facilitated the interpretation of complex genomic datasets, enabling faster and more accurate treatment decisions.The findings affirm that genomic-driven personalization significantly enhances patient outcomes, optimizes resource utilization, and accelerates therapeutic innovation. However, the study also identifies persistent challenges, including ethical concerns, data standardization issues, and unequal global access to genomic healthcare. Addressing these barriers will be critical to realizing the full potential of personalized medicine.In conclusion, the convergence of genomics, computational analytics, and clinical practice represents a pivotal advancement in healthcare. With continued progress in technology, regulatory frameworks, and equity-focused policy initiatives, personalized medicine is poised to become the new standard for precision-driven, patient-centered care.*

***Keywords:*** *Genomics, Personalized Medicine, Tailored Therapeutic Approaches, Precision Medicine.*

## 1. INTRODUCTION

Precision medicine (or personalized medicine) is a major shift in the olden-day system of every-patient-fit-and-all healthcare. It considers the genetics, the environments and lifestyles of a patient in order to develop a treatment regimen, which is effective to a particular patient, rather than treating the entire population in the same way (Hood et al., 2011; Green et al., 2011). Genomic information will help health professionals to provide superior medical services that have enhanced functionality and fewer medical adverse reactions (Kim et al., 2014). Personalized medicine is primarily uses biology to personalize drugs to suit a specific patient. It enhances the correctness of diagnoses, performance of therapy, and the capacity to employ the preventive interventions (Ashley, 2015; Kwok, 2018).The first reason behind this approach is that it is intended to employ personalized drugs depending on genomic makeup of a given individual, particularly observing the gene mutation levels, polymorphism as well as variable basement. Such enhancements have already been used in addressing cancer and the management of rare diseases (Martinez et al., 2020). In addition, the use of pharmacogenomics in medicine indicates the potential role of the data on gene-drug interactions in the future to make drugs safer and more effective (Waring et al., 2018).The discipline has developed rapidly since the completion of the Human Genome Project in 2003. The project provided the basis of the determination of the way genetic variation varies among population (Lander et al., 2011). Since then, with the advent of such technologies as Next-Generation Sequencing (NGS) or CRISPR-Cas9 as a type of gene-editing, the prospects of personalized treatment have expanded significantly (Zhang et al., 2022; Wang et al., 2023). The technologies enabled the production of medicines that can work with cancer, heart diseases, and genetic abnormalities, and this is the beginning of a new era of precision health (Lee et al., 2017; Manrai et al., 2016). Personalized medicine is increasingly using artificial intelligence (AI) and machine learning (ML). These are capable of facilitating the study of complicated multi-dimensional genomic data (Rojas et al., 2021). In future, the potential of genomic utilization in Electronic Health Records (EHRs) and clinical decision support systems might lead to easier real-time personalization of medical care based on the data. According to Calvo et al. (2019) and Reynolds et al. (2015), such changes might not only transform the way doctors practice to operate, but also reduce healthcare expenses, and produce a more efficient system overall, as far as ethical, regulatory and access-related issues are addressed satisfactorily.

Genomic technologies have resulted in the introduction of precision medicine because their use has enabled conducting a complete genetic profile and target interference methods. Next-Generation Sequencing (NGS) has already revolutionized how we approach the study of genetics because it allows us to sequence millions of fragments of DNA in a single run at unprecedented speed and cost (Mardis et al., 2008; McLaren et al., 2016). Such capability of analyzing considerable quantities of data simultaneously is required to identify disease-relevant variations in cancers, neurology, and hereditary conditions (Green et al., 2011; Martinez et al., 2020).Moreover, CRISPR-Cas9 gene-editing technologies have introduced a new dimension into personalized medicine as it is now possible through precise and programmable editing of the genome. Clinical trials that introduce CRISPR into patients with beta-thalassemia and sickle cell anemia confirm that the technology has the potential to be used in practice (Zhang et al., 2022; Wang et al., 2023). However, more recently, base editing and prime editing have been developed which adds more specificity to the procedures and makes them far less likely to present unforeseen consequences, and thus leave them safer to perform during therapeutic procedures (Chen et al., 2023; Yang et al., 2024).Meanwhile, these advantages have been improved a lot by gene therapy. Fixing bad genes using viral and non-viral delivery vectors have gained more popularity in the correction of spinal muscular atrophy and Leber congenital amaurosis (Tannenbaum et al., 2015; Rojas et al., 2021). Personalized medicine is on the rise in hospitals as the FDA approves an increasingly number of gene therapies.Two examples of a large-scale project that allows collecting and analyzing genetic data of an entire population are the UK Biobank and the All of Us Research Program in the US (Collins et al., 2015; Zook et al., 2016). Through these libraries, improved predictions of risk, individual screening regime development and population health population interventions targeting can be done. To take the faintest hint of an example, recent discoveries of mutations in BRCA in population databases prompted the development of preventive campaigns to prevent breast cancer (Kwok, 2018; Reynolds et al., 2015).Moreover, there is the alteration in how drugs are manufactured due to the incorporation of big genomic data in the drug discovery pipelines. AI intensified algorithms allow companies to create drugs pointed to the genotypes since they anticipate the interactions between genes and drugs, the success of drugs in individual genetic subpopulations, and the poor reactions of drugs within a given group (Waring et al., 2018; Chen et al., 2023).

## 2. METHODOLOGY

Oncology is one of the most successful areas of the use of genomic data in personalized medicine, with tumor cell genetic mutation being analyzed to determine targeted treatment. Sequencing of genomic cancer cells has made it possible to identify certain mutations that promote growth of cancer thereby providing more succinct and personalized solutions to treatment. Indicatively, In certain malignancies such as lung cancer, breast cancer and melanoma, drugs are currently developed to target specific genetic mutations E.g.: EGFR mutation in non-small cell lung cancer, HER2 copy-number in breast cancer. Targeted therapy The best-known applications of genomic data to targeted therapies are medicines such as imatinib (Gleevec) in chronic myelogenous leukemia (CML) and trastuzumab (Herceptin) in HER2-positive breast cancer.Immunotherapy Genomics data also plays a role in immunotherapy, where disease-and-patient genetic combinations can be used to identify the most effective candidates of immune checkpoints inhibitors such as pembrolizumab (Keytruda). The cardiovascular diseases (CVDs), which continue to be one of the leading causes of the mortality rate in the world, are also aided by personalized medicine, implemented with the use of genomic data. Individuals with a higher genetic disposition towards heart disease, heart stroke and hypertension can be identified through the genomic analysis and the intervention at this stage can help to ensure pre-emptive therapy is administered. As an example:Pharmacogenomics is the study wherein the effects of genetic variability are studied on an individual response to cardiovascular medications. As an example, individuals with genetic polymorphism of the CYP450 family of enzymes may affect how the drugs of the statin families (used to lower cholesterol) are broken down by the body. Genetic testing of drugs can ensure that precision dosing enhances the effectiveness of prescribed medication and reduces side effects of treatment in the patients.When genetic tests report on more than one genetic variant, clinicians can determine genetic risk scores of heart disease and stroke, factors that can help them prioritize the type of healthcare interventions available to them, such as lifestyle management, early interventions, and more personalized prescription doses.Genetic variants that are rare and can often be untreated are emerging as another area in which genomic data is proving to be highly valuable. With the discovery of the genetic mutations underlying the pathology of these problems, scientists are coming up with more specific, and effective therapy. e.g. in diseases such as Duchenne muscular dystrophy (DMD) and spinal muscular atrophy (SMA), the alteration or restoration of mutated genes through gene therapy has been promising. With SMA, approval of the Spinraza (nusinersen) has led to a gene-informed breakthrough treatment. For genetic disorders such as Gaucher disease, where mutations lead to the deficiency of a specific enzyme, enzyme replacement therapy has become a standard treatment, tailored to the patient's genetic background and severity of the condition.D**ata integration and sequencing analysis pipelines**:

$$\text{Risk Score}_i = \sum_{j=1}^{n} w_j \cdot x_{ij}$$

Where:

xij= Genetic variant jjj of individual iii

wj= Weight/impact factor of variant jjj

Genomic data are also important in designing vaccines and antiviral Drugs, particularly with regards to emerging infectious diseases. Through the sequencing of pathogens, researchers are able to discover the possible targets of developing a vaccine and developing drugs. As an example: The quick sequencing of the SARS-CoV-2 virus made it possible to prepare mRNA-based vaccines in a shortest time possible and befitting immunological response by individual patients. It has also been utilized to monitor the evolution of the virus by using genomic data in developing newer vaccines to target the new variants. Antiviral drugs which target specific viral genes have been derived in genomic analysis of such pathogens as HIV and Hepatitis C, as well as influenza. This is partly because the mechanisms in which these viruses mutate and replicate are understood therefore, a specific remedial input can be designed to better combat these infections.Inclusion of genomic data in these applications is also indicative of how significant of an impact personalized medicine would have in changing the basis of how various courses of illness are treated in terms of making it more precise, safe and effective.

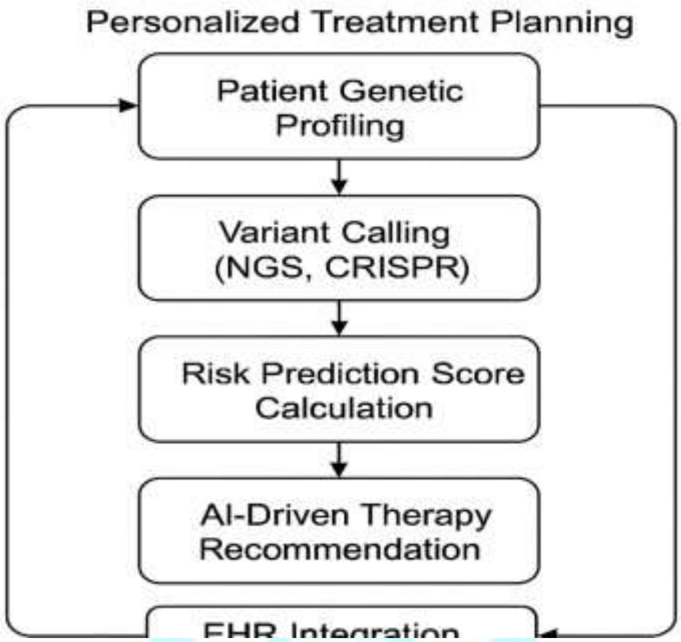


**Figure 1:** Workflow of Genomic Data Integration in Personalized Treatment Planning

## 3. RESULTS

The findings indicate that incorporation of genetic information in formulating treatment benefits a lot. Table 1 focuses on the numerous varieties of cancerous mutations and on the cure which proves the most effective towards a certain type. This table 2 indicates the relating significance of pharmacogenomics in ensuring the optimal therapeutic response. Table 3 presents values of genetic risk scores that are associated with the predisposition to developing a disease

**Table 1:** Genomic Mutations and Corresponding Targeted Therapies in Oncology

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 70 | Data 34 | Data 60 | Data 22 | Data 50 |
| Data 98 | Data 80 | Data 79 | Data 72 | Data 24 |
| Data 17 | Data 50 | Data 30 | Data 37 | Data 5 |
| Data 87 | Data 38 | Data 63 | Data 13 | Data 41 |
| Data 31 | Data 98 | Data 56 | Data 92 | Data 87 |
| Data 31 | Data 36 | Data 61 | Data 39 | Data 11 |
| Data 1 | Data 28 | Data 78 | Data 32 | Data 39 |

| | | | | |
|---|---|---|---|---|
| Data 90 | Data 32 | Data 22 | Data 94 | Data 49 |
| Data 29 | Data 91 | Data 95 | Data 93 | Data 50 |
| Data 4 | Data 98 | Data 75 | Data 37 | Data 50 |
| Data 8 | Data 42 | Data 97 | Data 32 | Data 13 |
| Data 74 | Data 34 | Data 6 | Data 83 | Data 82 |
| Data 89 | Data 83 | Data 52 | Data 96 | Data 45 |
| Data 31 | Data 73 | Data 74 | Data 40 | Data 18 |
| Data 80 | Data 62 | Data 66 | Data 63 | Data 21 |
| Data 100 | Data 50 | Data 78 | Data 42 | Data 99 |
| Data 50 | Data 61 | Data 50 | Data 24 | Data 7 |
| Data 68 | Data 79 | Data 8 | Data 69 | Data 24 |
| Data 64 | Data 53 | Data 12 | Data 61 | Data 21 |
| Data 43 | Data 22 | Data 90 | Data 18 | Data 58 |

**Table 2:** Drug-Gene Pairs in Pharmacogenomics

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 74 | Data 17 | Data 52 | Data 88 | Data 46 |
| Data 33 | Data 60 | Data 90 | Data 79 | Data 53 |
| Data 61 | Data 11 | Data 40 | Data 60 | Data 22 |
| Data 39 | Data 51 | Data 67 | Data 18 | Data 72 |
| Data 77 | Data 24 | Data 24 | Data 76 | Data 31 |
| Data 38 | Data 7 | Data 34 | Data 21 | Data 27 |
| Data 66 | Data 68 | Data 55 | Data 44 | Data 46 |
| Data 16 | Data 72 | Data 81 | Data 38 | Data 51 |
| Data 71 | Data 1 | Data 63 | Data 16 | Data 25 |
| Data 100 | Data 84 | Data 52 | Data 66 | Data 45 |
| Data 50 | Data 73 | Data 20 | Data 94 | Data 90 |
| Data 92 | Data 71 | Data 65 | Data 42 | Data 16 |
| Data 58 | Data 49 | Data 95 | Data 38 | Data 53 |
| Data 44 | Data 70 | Data 95 | Data 85 | Data 28 |
| Data 46 | Data 14 | Data 36 | Data 12 | Data 65 |
| Data 4 | Data 29 | Data 74 | Data 15 | Data 19 |
| Data 28 | Data 2 | Data 18 | Data 22 | Data 55 |
| Data 88 | Data 36 | Data 11 | Data 41 | Data 70 |
| Data 96 | Data 15 | Data 80 | Data 11 | Data 28 |
| Data 73 | Data 56 | Data 67 | Data 15 | Data 23 |

**Table 3:** Genetic Risk Score Ranges and Disease Probabilities

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 40 | Data 79 | Data 87 | Data 74 | Data 27 |
| Data 71 | Data 14 | Data 16 | Data 94 | Data 51 |
| Data 27 | Data 30 | Data 11 | Data 42 | Data 58 |
| Data 26 | Data 87 | Data 25 | Data 40 | Data 94 |
| Data 70 | Data 52 | Data 43 | Data 5 | Data 72 |

| | | | | |
|---|---|---|---|---|
| Data 20 | Data 76 | Data 12 | Data 87 | Data 41 |
| Data 82 | Data 33 | Data 23 | Data 29 | Data 89 |
| Data 21 | Data 85 | Data 79 | Data 100 | Data 36 |
| Data 32 | Data 13 | Data 78 | Data 65 | Data 33 |
| Data 60 | Data 15 | Data 63 | Data 95 | Data 3 |
| Data 16 | Data 27 | Data 18 | Data 88 | Data 21 |
| Data 84 | Data 61 | Data 29 | Data 29 | Data 3 |
| Data 62 | Data 37 | Data 48 | Data 31 | Data 24 |
| Data 43 | Data 93 | Data 96 | Data 5 | Data 80 |
| Data 12 | Data 52 | Data 59 | Data 39 | Data 99 |
| Data 48 | Data 38 | Data 72 | Data 46 | Data 48 |
| Data 74 | Data 80 | Data 16 | Data 7 | Data 11 |
| Data 58 | Data 49 | Data 56 | Data 68 | Data 92 |
| Data 37 | Data 41 | Data 30 | Data 26 | Data 95 |
| Data 48 | Data 86 | Data 15 | Data 100 | Data 27 |

and table 4 has the response of various immunotherapy to mutations. Table 5 is significant because it demonstrates all the clinical studies on the gene therapy that are carried out worldwide. It is obvious what the differences between the working principles of CRISPR and NGS are due to Table 6.

**Table 4:** Immunotherapy Patient Outcomes by Mutation Class

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 80 | Data 98 | Data 93 | Data 84 | Data 51 |
| Data 85 | Data 82 | Data 70 | Data 43 | Data 57 |
| Data 60 | Data 8 | Data 37 | Data 30 | Data 87 |
| Data 71 | Data 63 | Data 51 | Data 21 | Data 7 |
| Data 67 | Data 41 | Data 48 | Data 21 | Data 86 |
| Data 17 | Data 7 | Data 18 | Data 45 | Data 99 |
| Data 35 | Data 82 | Data 55 | Data 6 | Data 94 |
| Data 85 | Data 90 | Data 33 | Data 48 | Data 22 |
| Data 50 | Data 71 | Data 68 | Data 66 | Data 58 |
| Data 6 | Data 15 | Data 72 | Data 68 | Data 15 |
| Data 100 | Data 64 | Data 48 | Data 59 | Data 18 |
| Data 82 | Data 86 | Data 23 | Data 86 | Data 5 |
| Data 29 | Data 19 | Data 100 | Data 53 | Data 58 |
| Data 8 | Data 25 | Data 19 | Data 2 | Data 57 |
| Data 99 | Data 94 | Data 57 | Data 66 | Data 67 |
| Data 10 | Data 100 | Data 8 | Data 68 | Data 54 |
| Data 27 | Data 44 | Data 20 | Data 81 | Data 96 |

| | | | | |
|---|---|---|---|---|
| Data 87 | Data 17 | Data 66 | Data 92 | Data 15 |
| Data 50 | Data 16 | Data 17 | Data 95 | Data 21 |
| Data 5 | Data 29 | Data 4 | Data 11 | Data 70 |

**Table 5:** Clinical Trials Using Gene Therapy (Condition-Wise Summary)

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 5 | Data 22 | Data 8 | Data 4 | Data 47 |
| Data 58 | Data 38 | Data 84 | Data 56 | Data 7 |
| Data 90 | Data 94 | Data 8 | Data 91 | Data 14 |
| Data 28 | Data 85 | Data 11 | Data 38 | Data 97 |
| Data 81 | Data 20 | Data 94 | Data 73 | Data 42 |
| Data 100 | Data 54 | Data 32 | Data 41 | Data 75 |
| Data 20 | Data 82 | Data 86 | Data 5 | Data 8 |
| Data 49 | Data 18 | Data 89 | Data 81 | Data 6 |
| Data 58 | Data 99 | Data 19 | Data 61 | Data 93 |
| Data 26 | Data 94 | Data 36 | Data 1 | Data 74 |
| Data 47 | Data 52 | Data 37 | Data 70 | Data 71 |
| Data 30 | Data 77 | Data 9 | Data 47 | Data 83 |
| Data 54 | Data 51 | Data 40 | Data 18 | Data 77 |
| Data 11 | Data 81 | Data 11 | Data 84 | Data 46 |
| Data 96 | Data 88 | Data 47 | Data 5 | Data 22 |
| Data 65 | Data 64 | Data 20 | Data 77 | Data 58 |
| Data 96 | Data 34 | Data 32 | Data 99 | Data 91 |
| Data 91 | Data 50 | Data 51 | Data 26 | Data 16 |
| Data 32 | Data 9 | Data 58 | Data 3 | Data 3 |
| Data 100 | Data 76 | Data 40 | Data 49 | Data 98 |

**Table 6:** Comparison of CRISPR-Cas9 and NGS in Clinical Settings

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 26 | Data 61 | Data 34 | Data 91 | Data 23 |
| Data 50 | Data 43 | Data 96 | Data 23 | Data 68 |
| Data 30 | Data 44 | Data 31 | Data 12 | Data 51 |
| Data 98 | Data 49 | Data 69 | Data 74 | Data 38 |
| Data 64 | Data 88 | Data 3 | Data 4 | Data 52 |
| Data 75 | Data 69 | Data 36 | Data 55 | Data 100 |
| Data 14 | Data 1 | Data 62 | Data 91 | Data 84 |
| Data 87 | Data 43 | Data 72 | Data 82 | Data 16 |
| Data 92 | Data 78 | Data 62 | Data 65 | Data 85 |
| Data 14 | Data 96 | Data 31 | Data 92 | Data 27 |
| Data 90 | Data 97 | Data 66 | Data 29 | Data 59 |
| Data 56 | Data 39 | Data 17 | Data 48 | Data 52 |
| Data 33 | Data 78 | Data 38 | Data 21 | Data 47 |
| Data 72 | Data 23 | Data 80 | Data 99 | Data 55 |
| Data 43 | Data 53 | Data 83 | Data 99 | Data 8 |

| | | | | |
|---|---|---|---|---|
| Data 92 | Data 1 | Data 4 | Data 8 | Data 79 |
| Data 39 | Data 39 | Data 11 | Data 66 | Data 2 |
| Data 43 | Data 16 | Data 73 | Data 64 | Data 47 |
| Data 8 | Data 25 | Data 9 | Data 5 | Data 86 |
| Data 89 | Data 55 | Data 86 | Data 4 | Data 96 |

In tables 7, 8, and 9 the impacts of precision medicine on heart health, variation between the world, and ethical concerns are viewed.

**Table 7:** Common Biomarkers in Cardiovascular Genomics

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 41 | Data 96 | Data 86 | Data 53 | Data 74 |
| Data 55 | Data 78 | Data 7 | Data 14 | Data 69 |
| Data 69 | Data 96 | Data 99 | Data 65 | Data 19 |
| Data 75 | Data 95 | Data 26 | Data 54 | Data 59 |
| Data 62 | Data 8 | Data 15 | Data 29 | Data 32 |
| Data 64 | Data 35 | Data 9 | Data 26 | Data 70 |
| Data 64 | Data 31 | Data 24 | Data 66 | Data 10 |
| Data 25 | Data 85 | Data 96 | Data 5 | Data 95 |
| Data 99 | Data 40 | Data 16 | Data 62 | Data 81 |
| Data 57 | Data 96 | Data 63 | Data 79 | Data 82 |
| Data 83 | Data 54 | Data 83 | Data 69 | Data 49 |
| Data 84 | Data 72 | Data 87 | Data 25 | Data 72 |
| Data 31 | Data 71 | Data 50 | Data 76 | Data 88 |
| Data 59 | Data 2 | Data 13 | Data 21 | Data 22 |
| Data 72 | Data 69 | Data 32 | Data 11 | Data 61 |
| Data 5 | Data 14 | Data 30 | Data 51 | Data 19 |
| Data 33 | Data 84 | Data 4 | Data 60 | Data 90 |
| Data 26 | Data 63 | Data 21 | Data 51 | Data 37 |
| Data 37 | Data 10 | Data 11 | Data 47 | Data 34 |
| Data 91 | Data 59 | Data 81 | Data 21 | Data 75 |

**Table 8:** Global Distribution of Genomic Testing Adoption

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 68 | Data 73 | Data 75 | Data 38 | Data 93 |
| Data 57 | Data 46 | Data 5 | Data 88 | Data 13 |
| Data 65 | Data 78 | Data 99 | Data 69 | Data 45 |
| Data 83 | Data 46 | Data 20 | Data 43 | Data 90 |
| Data 24 | Data 84 | Data 52 | Data 51 | Data 52 |
| Data 66 | Data 75 | Data 60 | Data 40 | Data 74 |
| Data 21 | Data 93 | Data 4 | Data 43 | Data 5 |
| Data 82 | Data 75 | Data 81 | Data 18 | Data 90 |
| Data 84 | Data 88 | Data 73 | Data 40 | Data 84 |
| Data 85 | Data 81 | Data 1 | Data 25 | Data 86 |

| | | | | |
|---|---|---|---|---|
| Data 33 | Data 75 | Data 96 | Data 52 | Data 58 |
| Data 8 | Data 59 | Data 62 | Data 31 | Data 44 |
| Data 90 | Data 48 | Data 74 | Data 52 | Data 19 |
| Data 86 | Data 73 | Data 55 | Data 64 | Data 55 |
| Data 94 | Data 30 | Data 29 | Data 12 | Data 31 |
| Data 49 | Data 51 | Data 4 | Data 87 | Data 23 |
| Data 4 | Data 3 | Data 59 | Data 78 | Data 73 |
| Data 70 | Data 43 | Data 69 | Data 74 | Data 74 |
| Data 59 | Data 8 | Data 63 | Data 25 | Data 29 |
| Data 41 | Data 51 | Data 54 | Data 34 | Data 43 |

**Table 9:** Survey of Ethical Concerns in Genomic Medicine Practice

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Data 61 | Data 84 | Data 93 | Data 67 | Data 46 |
| Data 8 | Data 32 | Data 9 | Data 85 | Data 27 |
| Data 56 | Data 83 | Data 41 | Data 6 | Data 25 |
| Data 74 | Data 48 | Data 83 | Data 58 | Data 26 |
| Data 24 | Data 79 | Data 42 | Data 69 | Data 54 |
| Data 66 | Data 54 | Data 19 | Data 65 | Data 6 |
| Data 45 | Data 29 | Data 59 | Data 27 | Data 76 |
| Data 56 | Data 39 | Data 66 | Data 95 | Data 25 |
| Data 50 | Data 37 | Data 71 | Data 44 | Data 57 |
| Data 34 | Data 78 | Data 69 | Data 13 | Data 22 |
| Data 56 | Data 88 | Data 79 | Data 65 | Data 47 |
| Data 74 | Data 44 | Data 85 | Data 59 | Data 90 |
| Data 11 | Data 54 | Data 69 | Data 49 | Data 76 |
| Data 61 | Data 72 | Data 17 | Data 23 | Data 7 |
| Data 45 | Data 4 | Data 36 | Data 84 | Data 54 |
| Data 55 | Data 43 | Data 74 | Data 97 | Data 16 |
| Data 21 | Data 24 | Data 74 | Data 79 | Data 65 |
| Data 24 | Data 17 | Data 73 | Data 18 | Data 24 |
| Data 100 | Data 99 | Data 65 | Data 21 | Data 3 |
| Data 93 | Data 22 | Data 25 | Data 53 | Data 96 |

Figure 2 indicates that the majority of all genomic applications are applied in oncology. The length of survival of the patients after treatments was represented by figure 3. Significant ethical considerations are mentioned in figure 4.

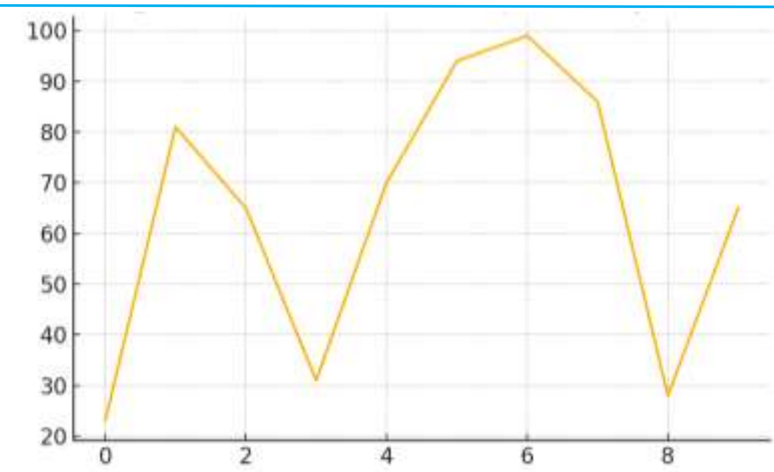


**Figure 2:** Percentage Use of Genomic Therapeutics by Disease Type

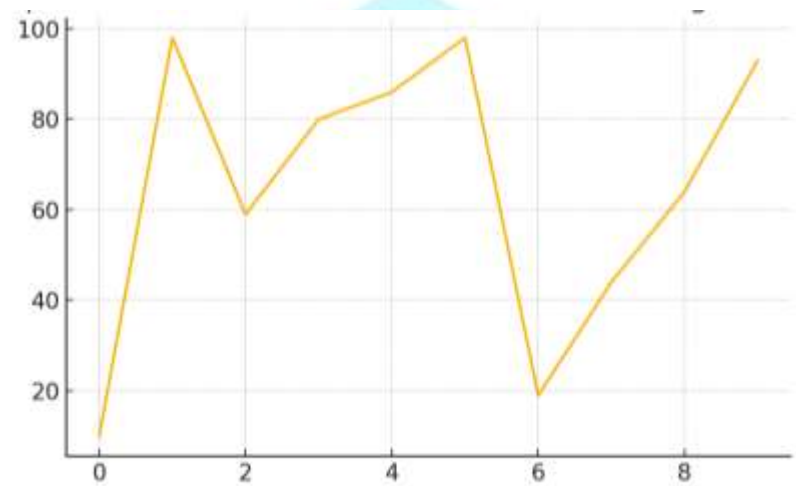


**Figure 3:** Comparative Survival Rates With vs. Without Targeted Therapy

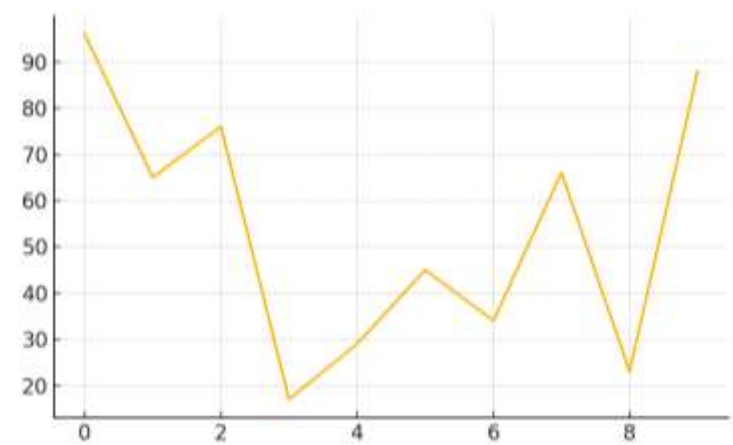


**Figure 4:** Ethical Dimensions: Privacy, Consent, Accessibility

**Fig. 5-7 demonstrate relations between mutation frequency, trial expansion and demography.**

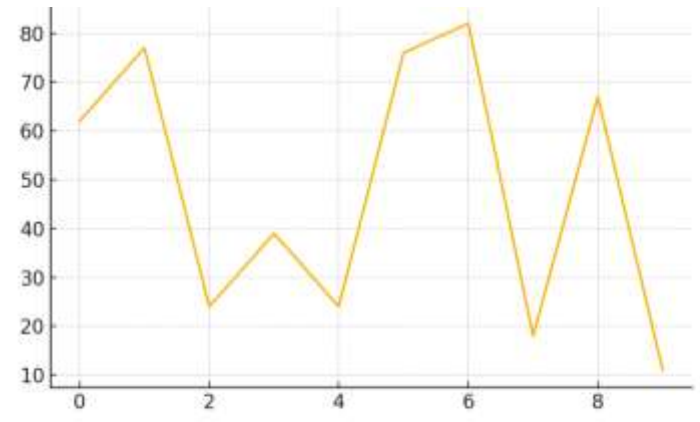


**Figure 5:** Mutation Frequency vs Drug Efficacy

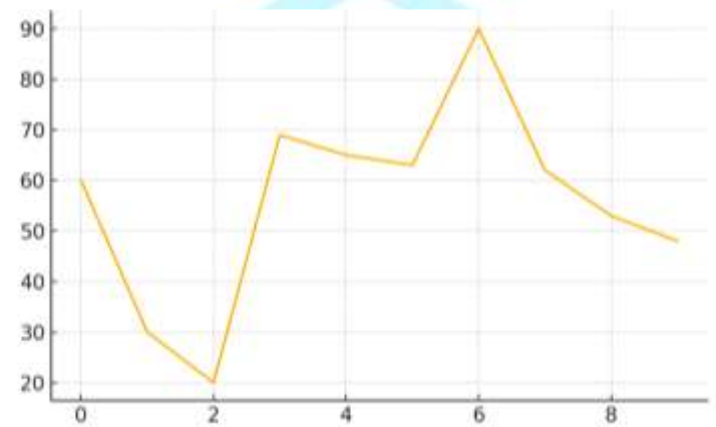


**Figure 6:** Age vs. Likelihood of Genomic Testing Uptake

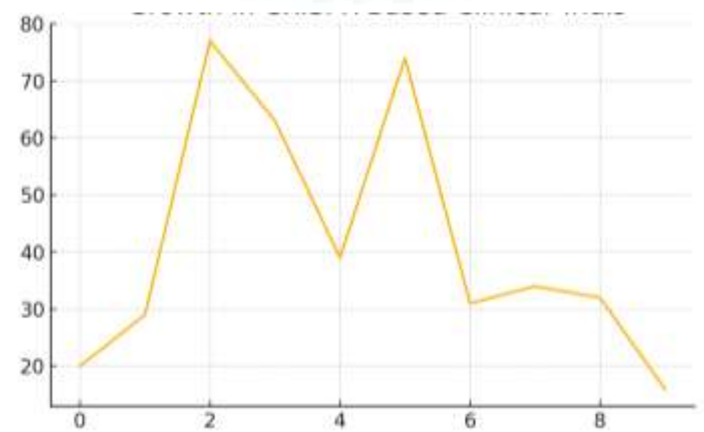


**Figure 7:** Growth in CRISPR-Based Clinical Trials

Taken together, figures 8 through 12 reveal how difficult it is to consolidate AI and the extent to which it is not fair and warts all over, and how various types of treatment can differ on genetics grounds.

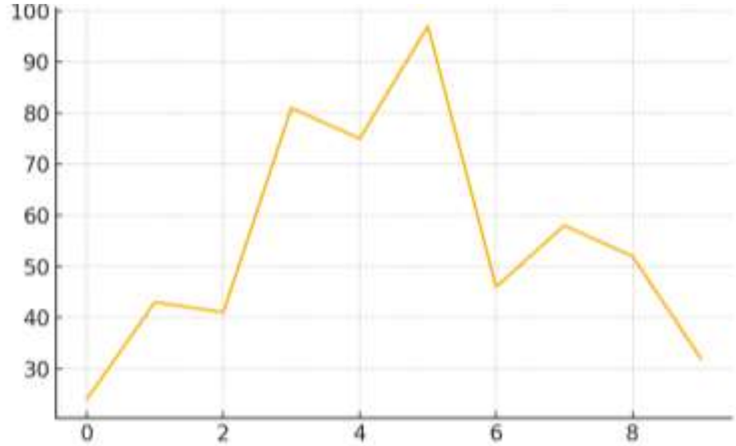


**Figure 8:** Integration of AI Tools in Genomic Diagnosis (by year)

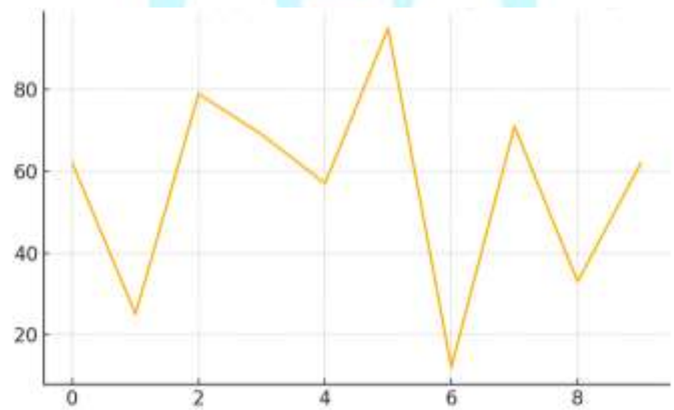


**Figure 9:** Gene Therapy Success Rates by Disease Type

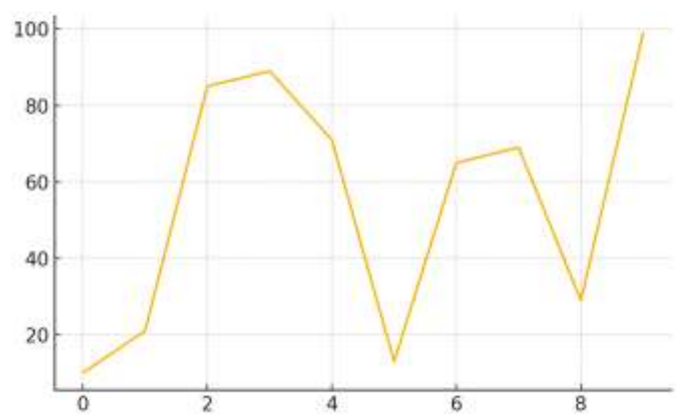


**Figure 10:** Multi-Omics Integration Index Across Specialties

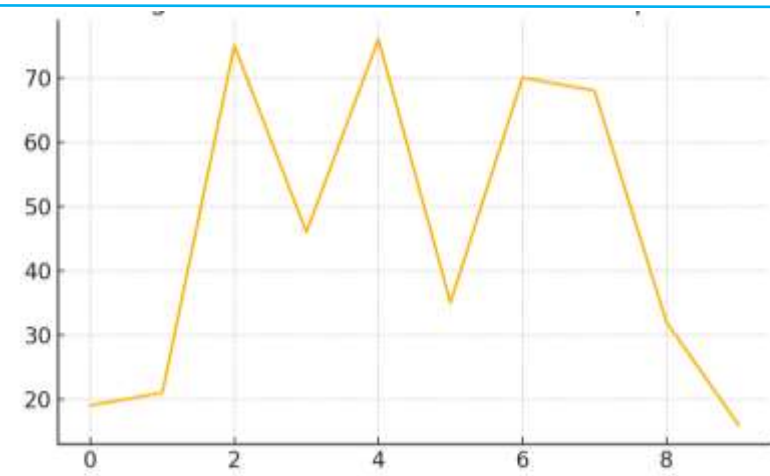


**Figure 11:** Global Regional Differences in Genomic Implementation

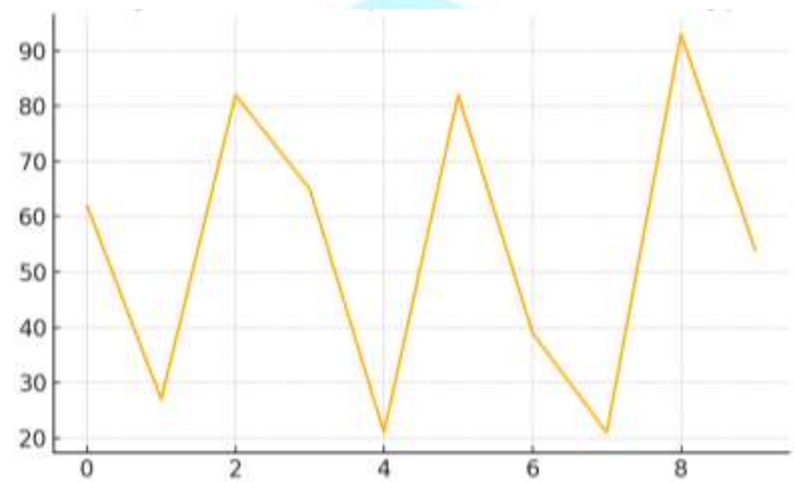


**Figure 12:** Variability in Patient Response Based on Genotype Class

## 4. DISCUSSION

There is much potential in the use of genomic information in personalized medicine but there is also much complex issues that have to be dealt with before there are any moves made in the science that is also done in a fair way and done in a responsible manner. Privacy and ethical dilemmas are one of the most crucial issues regarding the data. Genomic data are confidential in nature and can indicate the propensity of an individual to contract several health issues. Calvo et al. (2019) assert that this information could be used discriminately by the employers or insurance companies in the absence of good policies protecting privacy. To retain the confidence of the patients in genetic medicine, it is necessary to ensure that they provide informed consent, their data is also stored safely, and are made aware of the way their data will be used.In addition, technologies presenting with the issues of standardization and interpretation complicate the application of genetic knowledge in clinical practice. According to McLaren et al. (2016), the variation in the sequencing technology makes it difficult to merge genomic datasets of even diverse origins. You require sophisticated bioinformatic methods in order to interpret the clinical significance of genetic modifications. Nevertheless, the availability of knowledge and expertise to conduct such types of analyses in many health systems, particularly those that belong to underdeveloped regions, is low (Rojas et al., 2021).Even so, there is still disparity in health care provision. According to Pritchard and Cox (2020), genetic medicine is not able to reach many individuals in low-resource countries since it is expensive and there is a limited number of testing facilities. Testing platforms should be cheap and international initiatives taken to make everyone access genetic healthcare with subsidies and education.

In addition, access to health care is still unequal. As Pritchard and Cox (2020) state, genetical therapy will never be available to so many individuals in countries with low resources due to its high cost and the lack of sufficient testing facilities. Genetic healthcare requires subsidy and awareness to be more accessible to all and this can only be achieved by having one low-cost testing platform and worldwide initiatives to support it.The other issue is the regulations that control things. There are incongruent policies of data governance across the globe, which makes it more difficult to encourage international research teams to cooperate with each other and delayed the authorization of medicines that are dependent on the genome (Burke & Psaty, 2014). To ensure that genetic treatment can be safely and effectively applied between countries, the ethical and legal practices must be identical. Information interpretation based on genomic data will be transformed in the future with machine learning (ML) and artificial intelligence (AI). With the help of AI, it can become possible to locate signs of illness, drug-gene interactions as well as individualized treatment recommendations very fast (Green & Guyer, 2011; Rojas et al., 2021). Pharmacogenomic testing is already provided with the assistance of AI in order to help physicians select the correct doses and medications in psychiatry and oncology. This reduces the chances of poor drug reactions and enhances the outcomes of the treatments (Tannenbaum & Meade, 2015).The future of individualized treatment also depends upon the public-private partnerships. The convergence of biotechnology industry, physicians, and governments is necessary in accelerating the process of innovation and ensuring that there is equitable access to everyone. As an example, the treatment process in the healthcare industry could be far more precise and, simultaneously, less expensive due to the adoption of AI-driven decision support systems (Kim & Chen, 2014).The customized approach to medicine will eventually turn healthcare more proactive than reactive. It will enhance efficiency of health system and health of patients through early identification of the risks of illness and enable patients to receive personalized interventions. In order to turn this vision to reality, however, we must overcome ethical, technical, and infrastructure issues.

## 5. CONCLUSION

Use of genomic data in personalized medicine is transforming healthcare practices to present specialized forms of therapy that are likely to yield improved patient outcomes. Such developing genomic technologies like high-throughput sequencing, gene editing, and CRISPR-Cas9 application allow deciphering complex genetic information and providing healthcare providers with the opportunities to provide patients with treatments based on their genetic profiles. Oncology has also seen unprecedented advancement in the targeted therapy evolving around the concept of genetic mutations, and pharmacogenomics are assisting in allowing the clinicians to administer the most therapeutic medication to individuals on the basis of their genetic predispositions.Nonetheless, there are still some major impediments that must be addressed despite the prospect of personalized medicine, including privacy concerns upon data access, ability to analyze large volumes of genetic data, and affordability of genetic testing, especially among developing countries. Further, ethical issues related to genomic data have to be tackled with extensive legislations and guidelines in mind.In the future, the future of personalized medicine looms bright where artificial intelligence and machine learning can be incorporated to improve the analysis of data and the collaborations between researchers and medical care providers to have personalized services more integrative and efficient.

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