Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i7.7262

PRECISION MEDICINE IN INTERNAL MEDICINE: PERSONALIZED APPROACHES TO TREATMENT

Sana kainat[1], Dr. Rida Zahid[2*], Mohit Lakkimsetti[3], Tariq Rafique[4], Jehangir Ali Zuberi[5], Zakir Hidayatallah[6]

[1]MBBS Scholar ANMCH ISRA University Al Nafees Medical College and Hospital, Islamabad, Pakistan
[2*]MBBS, Department of Clinical Medicine, International School of Capital Medical University, Beijing, China
[3]MBBS, Mamata Medical College, Khammam, India
[4]Assistant Professor Dadabhoy Institute of Higher Education, Karachi, Pakistan
[5]Graduate Doctor, Department of Internal Medicine, Isra University Hyderabad, Pakistan
[6]Associate Professor, Department of Basic and Clinical Oral Sciences, Faculty of Dental Medicine, Umm alQura University, Makkah Mukarama

***Corresponding Author:** Dr. Rida Zahid
*****MBBS, Department of Clinical Medicine, International School of Capital Medical University, Beijing, China

ABSTRACT:
Background: Precision medicine represents a significant evolution in the field of internal medicine. Unlike traditional approaches that apply uniform treatments to all patients, precision medicine tailors healthcare based on individual patient characteristics.
Objective: This study aims to explore the current status, potential benefits, and challenges associated with the implementation of precision medicine in internal medicine.
Methods: The methodology involves the use of genomics, proteomics, and bioinformatics to identify unique genetic and molecular signatures in patients. By integrating controlled and clinical data, the study aims to enhance diagnostic accuracy and predict disease susceptibility, leading to personalized treatment strategies.
Results: The findings indicate that precision medicine can significantly improve patient outcomes by offering individualized treatment plans. The ability to detect specific genetic and molecular markers allows for targeted interventions, reducing adverse effects and providing a deeper understanding of complex diseases.
Conclusion: Precision medicine holds the promise of transforming internal medicine by providing more accurate and effective treatments. However, its development faces challenges such as the need for robust data infrastructure, interdisciplinary collaboration, and ethical considerations regarding the use of genetic material. Despite these hurdles, the future of internal medicine is poised to benefit immensely from the advancements in precision medicine.

KEYWORDS: Precision medicine, Internal medicine, Bioinformatics, Diagnostic accuracy Disease susceptibility, Targeted interventions, Genetic markers, Molecular markers, Data infrastructure, Ethical considerations, and Genetic material.

INTRODUCTION:

Precision medicine has brought personalized care from one-size-fits-all to revolutionize internal medicine [1]. The strategy uses new knowledge from human genomics, proteomics, and bioinformatics services to adapt medical care to the individual patient based on their unique genetic, molecular, and clinical profile [2, 3]. It aims to provide better therapies, which more precisely target the diseases afflicting this or that patient and so improve their outcome while reducing harmful side effects [4, 5]. Precision medicine must remember that a patient's illness is formed by a combination of genetic and environmental factors. Analysis of a patient's genome, however, can help medical practitioners find specific biomarkers associated with disease susceptibility, development, and reaction to treatment [6]. This in turn opens a way for designing tailored treatments that will work better for the patient in question. In cancer research, for example, precision medicine has led to the discovery of targeted therapies aimed specifically at cancer cells with particular genetic mutations [7]. This allows healthy cells to be spared and side effects reduced. Precision medicine also promotes more accurate diagnosis [8]. Modern diagnostic tools and techniques such as next-generation sequencing can provide early detection of diseases at a molecular level--often before symptoms materialize [9, 10]. Such intervention in advance means improved management of disease and a better prognosis. Also, as an important part of precision medicine, pharmacogenomics researches how the response a person has to drugs is influenced by his genes [11]. This understanding can help select both the most effective medication for each patient and what dosage it should be, minimizing the risk of adverse reactions and increasing the likelihood that treatment will succeed [12].

Table 1: Introduction and Evolution

Statement	Reference
Precision medicine has brought personalized care from one-size-fits-all to revolutionize internal medicine.	[1]
The strategy uses new knowledge from human genomics, proteomics, and bioinformatics services to adapt medical care to the individual patient based on their unique genetic, molecular, and clinical profile.	[2, 3]

Table 2: Objectives and Benefits

Statement	Reference
It aims to provide better therapies, which more precisely target the diseases afflicting this or that patient and so improve their outcome while reducing harmful side effects.	[4, 5]
Precision medicine must remember that a patient's illness is formed by a combination of genetic and environmental factors.	
Analysis of a patient's genome, however, can help medical practitioners find specific biomarkers associated with disease susceptibility, development, and reaction to treatment.	[6]
This in turn opens a way for designing tailored treatments that will work better for the patient in question.	
In cancer research, for example, precision medicine has led to the discovery of targeted therapies aimed specifically at cancer cells with particular genetic mutations.	[7]
This allows healthy cells to be spared and side effects reduced.	
Precision medicine also promotes more accurate diagnosis.	[8]

Table 3: Techniques and Applications

Statement	Reference
Modern diagnostic tools and techniques such as next-generation sequencing can provide early detection of diseases at a molecular level--often before symptoms materialize.	[9, 10]
Such intervention in advance means improved management of disease and a better prognosis.	
As an important part of precision medicine, pharmacogenomics researches how the response a person has to drugs is influenced by his genes.	[11]
This understanding can help select both the most effective medication for each patient and what dosage it should be, minimizing the risk of adverse reactions and increasing the likelihood that treatment will succeed.	[12]

Table 4: Challenges and Future Prospects

Statement	Reference
However, applying precision medicine in internal medicine is beleaguered by many obstacles. These include the need for extensive, well-organized data, sophisticated bioinformatics tools, interdisciplinary collaboration, and moral concerns regarding genetic information privacy.	[13]
Nevertheless, in the future, we can expect that the vast benefits of precision medicine will become apparent as treatments become more effective, personalized, and adapted to specific individual characteristics.	[14]

However, applying precision medicine in internal medicine is beleaguered by many obstacles. These include the need for extensive, well-organized data, sophisticated bioinformatics tools, interdisciplinary collaboration, and moral concerns regarding genetic information privacy [13]. Nevertheless, in the future, we can expect that the vast benefits of precision medicine will become apparent as treatments become more effective, personalized, and adapted to specific individual characteristics [14].

Table 1: A table summarizing key aspects of precision medicine in internal medicine:

Aspect	**Description**
Definition	medical care tailored to individual genetic, molecular, and clinical profiles
Key Components	Genomics, proteomics, bioinformatics, pharmacogenomics
Goals	Improve patient outcomes, enhance diagnostic accuracy, and reduce adverse effects.
Applications	Oncology (targeted therapies), cardiology, endocrinology, infectious diseases
Benefits	Tailored treatment plans Early disease detection Improved disease management side effects
Challenges	Data infrastructure needs Interdisciplinary collaboration and Ethical concerns regarding genetic data privacy.
Technologies Used	Next-generation sequencing, biomarker analysis, advanced diagnostic tools
Examples	Targeted cancer therapies Personalized medication dosing - Risk prediction for genetic diseases
Ethical Considerations	Privacy of genetic data, informed consent, potential for genetic discrimination

In the field of internal medicine, this table provides an overview of the key elements and considerations of precision medicine.

METHOD: .

It involves a combination of cutting-edge technologies and big data exhaustive analysis by a wide range of people from all disciplines, as well as personally tailoring each patient's care [15, 16]. The process can be broadly outlined in the following steps:

Patient Selection and Data Collection: Until now, the first stage in precision medicine work has been to identify which patients may benefit from it. Patient history itself, combined with their living habits (what they eat drink, smoke, or otherwise do that affects their health), and any relevant clinical data are collected. Advanced diagnostics like next-generation sequencing (NGS) generate genetic and molecular information on patients [17]. This could include whole genome sequencing(WGS), exome sequencing (ES), and targeted gene panels.

1. **Data Integration and Analysis:** In this process, the collected data is pooled into a single, unified patient profile using advanced bioinformatics software. It is at this level that analyses of genetic polymorphisms, gene expression profiles, proteomic data sets, and other biomarkers are all integrated. Machine learning algorithms and artificial intelligence (AI) often have to be employed to neither miss out nor wrongly detect any patterns or relationships.
2. **Identification of Biomarkers:** Meanwhile, the search is on for individual genetic or molecular markers of illness as well as ways to treat these diseases and gauge the outcomes. These markers are important not only in selecting specific therapies (a method known as precision medicine) but also make a major difference between one's suffering and peace of mind upon recovery from cancer. It's obvious that if you don't know whether you've got BRCA1/2 mutations in breast cancer or EGFR mutations in lung cancer then chances are treatment ain't gonna be much use to you.
3. **Development of Personalized Treatment Plans** Based on identified biomarkers and the patient's profile, personalized treatment plans are established. The use of Wnts is planned This includes choosing specific targeted therapies, careful titration of medicines, or recommending lifestyle changes to enhance genetic healing and minimize bad side-effects caused by drugs. Pharmacogenomic data provides help with ensuring that drugs are given at a proper dose and in the right form to achieve maximum therapeutic effect with minimum toxicity.

4. **Implementation and Monitoring:** Executing the personalized treatment plan and monitoring results at regular intervals. The situation and treatment plan for each patient are constantly monitored. Real-time data collection and analysis allow for changes in the treatment plan to be made at the correct moments in time.
5. **Ethical and Collaborative Considerations:** Ethical and Professional Considerations of Collaboration and Ethical concerns, such as patient consent and data privacy, are cited. Collaboration involving various medical professionals provides the essential groundwork for the successful implementation of precision medicine. Genetic counsellors, bioinformaticians or other experts in their field (who themselves also have to respect such a code) are all involved and quite necessary.
By using these measures, internal medicine expects to give more effective care that takes account of individual differences and is ultimately more beneficial to patients.

Table 2: A table summarizing the method for implementing precision medicine in internal medicine:

Step	Description
Patient Selection and Data Collection	Identify suitable patients; collect detailed histories, lifestyle information, and clinical data using advanced diagnostics like NGS.
Data Integration and Analysis	Integrate genetic, molecular, and clinical data using bioinformatics tools; apply machine learning and AI to identify patterns and correlations.
Identification of Biomarkers	Identify genetic and molecular biomarkers that influence disease and treatment response, guiding the development of targeted therapies.
Development of Personalized Treatment Plans	Create individualized treatment plans based on identified biomarkers, including selecting targeted therapies and optimizing medication dosages.
Implementation and Monitoring	Implement the treatment plan with continuous monitoring and adjustments based on real-time data to assess efficacy and manage side effects.
Ethical and Collaborative Considerations	Address ethical issues like patient consent and data privacy; ensure collaboration among healthcare providers and specialists.

Using this structured table, one can see an overall diagram of how to implement precision medicine into internal medicine, and it shows every single step with the main components thereof.

Table 3: Patient Selection and Data Collection

Aspect	Description
Patient Identification	Identify patients likely to benefit from precision medicine.
Data Types Collected	Clinical histories, lifestyle information, genetic data.
Diagnostic Techniques	Next-generation sequencing (NGS), exome sequencing, and targeted gene panels.

Table 4: Data Integration and Analysis

Aspect	Description
Data Integration	Combine genetic, molecular, and clinical data.
Bioinformatics Tools	Use software and algorithms to analyze complex data sets.
Analytical Methods	Machine learning, artificial intelligence (AI), statistical analysis.

Table 5: Identification of Biomarkers

Aspect	Description
Biomarker Types	Genetic variants, gene expression profiles, proteomics data.
Identification Methods	Genomic sequencing, molecular profiling, biomarker analysis.
Clinical Relevance	Biomarkers that predict disease risk, progression, and treatment response.

Table 6: Development of Personalized Treatment Plans

Aspect	Description
Treatment Selection	Choose targeted therapies based on biomarker data.
Medication Optimization	Adjust drug dosages to individual genetic profiles.
Lifestyle Recommendations	Provide advice on diet, exercise, and other lifestyle factors.

Table 7: Implementation and Monitoring

Aspect	Description
Treatment Implementation	Initiate personalized treatment plans.
Continuous Monitoring	Regularly assess treatment efficacy and side effects.
Data-Driven Adjustments	Modify treatment based on real-time patient data.

Table 8: Ethical and Collaborative Considerations

Aspect	Description
Ethical Issues	Address consent, data privacy, and potential genetic discrimination.
Patient Consent	Ensure patients are fully informed about their treatment.
Interdisciplinary Collaboration	Foster cooperation among healthcare providers, genetic counsellors, bioinformaticians, and specialists.

In these tables, each step has been extended into a series of more detailed elements to help give a complete picture of the method for implementing precision medicine in internal medicine.

RESULT:

The implementation of precision medicine in internal medicine has obtained some rewarding results that offered a different path for the future of medical science coming from what could only be called genomic experiments [18]. Precision medicine guides medical intervention according to the individual patient's unique genetic and molecular makeup. To this end, technologies of genomics, proteomics, and bioinformatics are employed. A change in thinking has brought many results covariates such as genetic or molecular biomarkers, and treatments tailored to the individual have been shown though not always successful [19, 20]. Going back a few decades and entering desert medicine from science there has already begun another rise -legislation fighter provides a singular example. For example, targeted therapies aimed at specific genetic mutations or molecular pathways have provided better control of and management of diseases than ever before. Oncology is a case where treatments such as tumour kinase inhibitors plus immunotherapy are performing very well right now. Since genetic information started to be integrated with clinical data in Medicine, diagnostic accuracy has risen a lot. Besides, accepting "that diseases can be seen as a molecular event early on and one has to take action actively to prevent them from developing further" is particularly crucial for understanding genetic predispositions to certain diseases, and then taking steps against them before they have a chance to manifest themselves (as already planted seeds) also makes sense.

Precision medicine lowers the adverse effects of traditional treatments through individual genetic profiles determining the treatment plan. Understanding the pharmacogenomics of drug metabolism and response allows for a more accurate dosage personalized to patients. This in turn reduces side effects from medications. New types of treatment for genetic diseases like gene therapies and RNA-based medicines have emerged. With these innovative therapies, patients are now able to be rid of any treatment for otherwise untreatable diseases since the underlying disorder has effectively been removed. Precision medicine has put behind traditional Therapy Patterns. It has brought forth therapies peculiar to underlying causes, and given new hope to those patients who had nothing left but despair. In terms of broader public health benefits, the precision medicine approach has real potential. By understanding variations in genetic populations and decoding disease susceptibility, healthcare systems can set more efficient prevention systems up at the population level together with screening programs that benefit the masses; this in turn reduces the overall burden of disease. However, challenges remain. Maintaining robust data infrastructure, interdisciplinary collaboration, regulatory considerations and equitable access to genetic testing and therapies are still problems that must be solved before precision medicine reaches its full potential in transforming internal medicine as we know it.

Table 9: Improved Treatment Efficacy

Outcome	Description
Personalized Treatment Plans	Tailored to individual genetic and molecular profiles, leading to enhanced therapeutic effectiveness.
Targeted Therapies	Effective against specific genetic mutations or molecular pathways, improving disease control.
Enhanced Disease Management	Effective against specific genetic mutations or molecular pathways, improving disease control.

Table 10: Enhanced Diagnostic Precision

Outcome	Description
Early Disease Detection	Molecular-level diagnostics enable early identification of diseases, facilitating timely interventions.
Genetic Risk Assessment	Identification of genetic predispositions to diseases allows for proactive preventive measures.
Improved Accuracy in Diagnosis	Integration of genetic data with clinical information improves diagnostic accuracy.

Table 11: Reduced Adverse Effects

Outcome	Description
Personalized Medication Plans	Optimization of drug selection and dosage based on genetic profiles reduces adverse drug reactions.
Minimized Treatment Side Effects	Tailored therapies mitigate adverse effects associated with traditional treatments.
Improved Patient Safety	Better tolerance and adherence to treatments due to reduced adverse events.

DISCUSSION:

Precision medicine turns out to be an innovative approach in internal medicine; it regards the individual as the unit and takes into account personalized patient genetic traits, conditions of the molecules, and race characteristics then treatment oneself out. This brings the promise of more favourable outcomes for patients and improved diagnoses, but it is a far cry from 'standardized treatments.' Each patient is a source of original clinical findings, and the drugs are chosen in keeping with that particular person's inherited predisposition By analyzing genetic and molecular profiles, precision medicine helps medical practitioners tailor treatment plans to make it suitable for each person or family's unique genetic background. The personalized approach is beginning to show a major result in oncology.

Targeted therapies aimed at specific genetic mutations or biomarkers have led to better response rates and survival rates for patients. Similarly, in cardiology and neurology, knowledge of genetic predispositions mentioned above provides an opportunity for therapies to be chosen that are more likely to work for the individual patient; and treatment efficacy is all the higher when such a course has been followed through. With both genetic data and clinical information, diagnosis becomes more accurate. It allows us to diagnose diseases at the molecular level simply by taking a sample of blood before they cause any symptoms. This not only enables us to better manage diseases but also enables us to prevent measures to be taken for illness. For example, genetic testing may reveal which individuals are at the highest risk for certain cancers or cardiovascular diseases; such information can then guide secondary screening and lifestyle changes that lower the risk of disease occurrence as a whole. Personalized medicine can reduce the harm caused by medicines because it matches the drugs selected and dosages given to individual genetic characteristics. With pharmacogenomic information concerning drug response and metabolism, the clinician can choose medications that are most suitable for a particular person; this minimizes adverse effects and thereby makes treatment safer. This approach has been especially useful when faced with chronic illnesses that require long-term drug maintenance. Precision medicine has produced new treatment techniques: gene therapies or those using RNA that go after individual genetic defects or pathways will now emerge as a means to cure diseases. These developments provide hope for patients with

rare genetic illnesses, diseases hitherto always devastating or untreatable. Traditional forms of therapy failed to produce even partial success or were very limited in efficacy. Implementing precision medicine demands the establishment of efficient large-scale genetic and clinical databases as well as appropriate equipment. Challenges include interoperability of data, protection for privacy, and secure exchange of genetic information across different healthcare systems and research facilities... Successful implementation of precision medicine depends on our cooperation as healthcare providers with geneticists, bioinformaticians and other experts. Interdisciplinary cooperation ensures whole patient care and management, from genetic testing and data analysis to treatment planning and monitoring. This guarantees a bottom-up, integrated approach to precision medicine. Thought must be given to ethical questions: how is a patient confessed, what is the legal position on genetic information privacy, and are there any implications for genetic discrimination that have to be handled with particular attention? Aspects of regulation affecting genetic testing, data privacy and how to secure fair and ethical use are indispensable if patient rights are to be preserved and the ethical background of precision medicine preserved. For precision medicine to benefit a diverse patient population across the board, access to genetic testing and personalized therapies has to be equitable and individual.

Addressing gaps in access to healthcare, the affordability of medical treatment Programs and genetic knowledge is essential If more people are to get hold of opportunities from these techniques based on precision medicine. What new knowledge and trouble-free access does the future of internal medicine hold thanks to precision medicine? Progress in the field of genomics, more AI-driven data analysis (as well) and various personalized therapeutic innovations will no doubt help extend precision medicine into a broader phase, becoming applicable to more fields. Shared among global healthcare systems and the fruit will surely be richer still In clinical practice as well as research, which has already seen such growth courses in infrastructure development it is a stepping up of collaboration that will count most. In the end, whole patient care can only be achieved through combining multitudes of human skills, ranging from genetic testing and data analysis to making sound treatment plans that are vigilant about their regularity Underfoot; an all-around approach for precision medicine.

CONCLUSION:

Precision medicine is a revolutionary technique in internal medicine. It offers treatments personalized and geared to individual genetic and molecular perspectives. This dramatic break holds great expectations for not only improving patient outcomes but also for perfecting diagnostic accuracy and dwelling on new therapeutics across different medical fields. Genetic and molecular data is utilized by precision medicine in the crafting of treatment plans to address the particular gene alterations or biomarkers driving a patient's illness. This approach has proven more effective than general treatment in treating conditions such as cancer, cardiovascular disease, and rare inherited diseases. When clinical data is linked to genetic information it can enhance diagnosis and bring about early detection of diseases, offering the basis for intervention strategies ahead of time. Early intervention based on these findings not only can improve patient outcomes. It also allows individuals to take timely precautions aimed at avoiding disease. When medications are tailored to genetic profiles, adverse drug reactions decrease significantly and the treatment becomes safer. Pharmacogenomics turns medicine on its head, picking medicines and dosages to increase patient tolerance and compliance with intervention programs for good health. Various entirely new methods for treatment have been birthed through precision medicine, including gene therapies and other RNA-based treatments that target the root genetic mechanisms of diseases such as treating genetic diseases by modifying DNA or rNA at some stage. These new developments open up fresh paths for solving diseases previously untreated and thoroughly new life strategies to improve the quality of life for patients. Although it has had success, precision medicine is confronted with challenges like the complex integration of data, interdisciplinary collaboration and ethical considerations as well as ensuring equal access to technology. Solving these problems will be

crucial for realizing the full potential of precision medicine and for that reason its widespread use in clinical practice. In the years to come, continued progress in genomic research, bioinformatics and AI-driven analysis will widen the sphere and impact of precision medicine. Providers of medical care, researchers, policymakers and industry players will have to pool their strengths if personalized healthcare delivery is going to be developed in innovative ways to drive down barriers. In summary, precision medicine can be seen as a turning point in internal medicine. It gives rise to tailored therapies that increase treatment outcomes, patient security, and direction of work for a patient's personal health future. Integrating genetic insight with clinical work means precision medicine has the potential to rewrite the book on disease treatment, give the patient definition there and now by informed therapy choices, towards new and more successful methods of patient-oriented medicine moving to adulthood. Seizing these openings and coping with the pressures that come from them will be key in making precision medicine more than just a transitory fashion, one that has an even better outcome for patients around the world.

REFERENCES:

1. Kosorok, M.R. and E.B. Laber, *Precision medicine.* Annual review of statistics and its application, 2019. **6**(1): p. 263-286.
2. Johnson, K.B., et al., *Precision medicine, AI, and the future of personalized health care.* Clinical and translational science, 2021. **14**(1): p. 86-93.
3. Gambardella, V., et al., *Personalized medicine: recent progress in cancer therapy.* Cancers, 2020. **12**(4): p. 1009.
4. Ho, D., et al., *Enabling technologies for personalized and precision medicine.* Trends in biotechnology, 2020. **38**(5): p. 497-518.
5. Tsimberidou, A.M., et al., *Review of precision cancer medicine: Evolution of the treatment paradigm.* Cancer treatment reviews, 2020. **86**: p. 102019.
6. Seyhan, A.A. and C. Carini, *Are innovation and new technologies in precision medicine paving a new era in patient-centric care?* Journal of Translational Medicine, 2019. **17**(1): p. 114.
7. Hulsen, T., et al., *From big data to precision medicine.* Frontiers in medicine, 2019. **6**: p. 34.
8. Tsiatis, A.A., et al., *Dynamic treatment regimes: Statistical methods for precision medicine*. 2019: Chapman and Hall/CRC.
9. Erikainen, S. and S. Chan, *Contested futures: envisioning "Personalized," Stratified," and "Precision" medicine.* New Genetics and Society, 2019. **38**(3): p. 308-330.
10. Jacob, M., et al., *Metabolomics toward personalized medicine.* Mass spectrometry reviews, 2019. **38**(3): p. 221-238.
11. Ciardiello, F., et al., *Clinical management of metastatic colorectal cancer in the era of precision medicine.* CA: a cancer journal for clinicians, 2022. **72**(4): p. 372-401.
12. MacEachern, S.J. and N.D. Forkert, *Machine learning for precision medicine.* Genome, 2021. **64**(4): p. 416-425.
13. Schork, N.J., *Artificial intelligence and personalized medicine.* Precision medicine in Cancer Therapy, 2019: p. 265-283.
14. Kyrochristos, I.D. and D.H. Roukos, *Comprehensive intra-individual genomic and transcriptional heterogeneity: Evidence-based Colorectal Cancer Precision Medicine.* Cancer treatment reviews, 2019. **80**: p. 101894.
15. Vitale, A., et al., *Treatment of hepatocellular carcinoma in the precision medicine era: from treatment stage migration to therapeutic hierarchy.* Hepatology, 2020. **72**(6): p. 2206-2218.
16. Padmanabhan, S. and A.F. Dominiczak, *Genomics of hypertension: the road to precision medicine.* Nature Reviews Cardiology, 2021. **18**(4): p. 235-250.
17. Agache, I. and C.A. Akdis, *Precision medicine and phenotypes, endotypes, genotypes, region types, and other types of allergic diseases.* The Journal of Clinical Investigation, 2019. **129**(4): p. 1493-1503.
18. Schüssler-Fiorenza Rose, S.M., et al., *A longitudinal big data approach for precision health.* Nature Medicine, 2019. **25**(5): p. 792-804.

19. Blasiak, A., J. Khong, and T. Kee, *CURATE. AI: optimizing personalized medicine with artificial intelligence.* SLAS TECHNOLOGY: Translating Life Sciences Innovation, 2020. **25**(2): p. 95-105.
20. Zeggini, E., et al., *Translational genomics and precision medicine: Moving from the lab to the clinic.* Science, 2019. **365**(6460): p. 1409-1413.