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# PRECISION MEDICINE AND PHARMACOGENOMICS: TRANSFORMING PERSONALIZED TREATMENT AND CLINICAL DECISION-MAKING

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## ABSTRACT

*Precision medicine has emerged as an important development in modern healthcare, focusing on the customization of medical treatment according to individual genetic, biological, environmental, and lifestyle characteristics. Unlike traditional medical approaches that generally apply similar treatment strategies to large patient populations, precision medicine recognizes that individuals may respond differently to the same disease treatment or medication. Pharmacogenomics, an essential component of precision medicine, examines how genetic variations influence drug metabolism, effectiveness, and the risk of adverse drug reactions. By incorporating genetic information into clinical decisions, healthcare professionals can make more informed choices regarding medication selection, dosage, and treatment planning. This research examines the role of precision medicine and pharmacogenomics in transforming personalized treatment and clinical decision-making. It explores their applications in cardiovascular diseases, cancer treatment, mental health, infectious diseases, and chronic conditions. The study also investigates challenges associated with genetic testing, healthcare costs, data privacy, professional training, and unequal access to genomic technologies. A qualitative descriptive methodology is adopted through the analysis of existing scientific literature and clinical guidelines. The findings indicate that pharmacogenomic information can support safer medication use and improve treatment selection when reliable evidence connects specific genetic variations with particular medicines. However, genetic information must be interpreted alongside other clinical factors, including age, kidney and liver function, medical history, and drug interactions. The research concludes that precision medicine can strengthen healthcare decision-making through evidence-based personalized treatment, but its successful implementation requires accessible genetic testing, updated clinical guidelines, trained professionals, ethical data management, and equitable healthcare policies.*

## KEYWORDS

*Precision Medicine, Pharmacogenomics, Personalized Treatment, Genetic Testing, Clinical Decision-Making, Drug Response, Genomic Medicine, Patient Safety.*

## INTRODUCTION

Modern healthcare has traditionally relied on standardized treatment approaches in which patients diagnosed with similar medical conditions are often prescribed comparable medicines and treatment plans. Although this approach has improved the management of many diseases, it does not always account for the biological differences that influence individual responses to treatment. Patients may respond differently to the same medication because of variations in their genetic composition, metabolism, age, lifestyle, environmental exposure, and existing health conditions. Some individuals may experience effective therapeutic results, while others may develop serious adverse reactions or receive limited clinical benefits. These differences have

encouraged the development of precision medicine, an approach that aims to provide healthcare according to the individual characteristics of each patient. Evans et al. (2024) explain that precision medicine combines genomic knowledge, clinical information, and data analysis to support more individualized approaches to disease prevention and treatment.Precision medicine represents a shift from a generalized treatment model toward a more individualized healthcare strategy. It uses information from genetics, molecular biology, medical history, lifestyle, and environmental factors to understand disease development and identify suitable treatment options. Genomic testing can help identify variations associated with disease risk, drug response, and certain inherited conditions. Other technologies, including molecular diagnostics, advanced imaging, artificial intelligence, and clinical data analysis, can provide additional information for medical decision-making. The purpose is not simply to identify a patient's genetic characteristics but to combine relevant biological and clinical information to improve the selection and management of treatment. Evans et al. (2024) emphasize that precision medicine has applications in both specialized medical services and primary healthcare, although its wider implementation requires attention to affordability, evidence, and healthcare inequalities.Pharmacogenomics is one of the most important areas of precision medicine because it examines the relationship between genetic variations and individual responses to medicines. Genetic differences can influence how quickly the body absorbs, processes, transports, and eliminates particular drugs. These variations may affect whether a medicine produces the expected therapeutic response, becomes less effective, or causes unwanted side effects. Pharmacogenomic testing can identify selected genetic variants that are clinically relevant to particular drug treatments. Healthcare professionals can use this information, where supported by evidence and clinical guidelines, to consider alternative medicines or adjust treatment doses. Donnelly et al. (2024) explain that pharmacists and other healthcare professionals can use pharmacogenomic information alongside clinical factors to support individualized medication selection and improve medication-related outcomes.

The importance of pharmacogenomics can be understood through the role of drug-metabolizing enzymes and transport proteins. Certain genes influence enzymes responsible for processing medicines in the body. Variations in genes such as CYP2D6, CYP2C19, CYP2C9, and CYP3A5 may influence the metabolism of specific drugs. Depending on the genetic variation, an individual may metabolize a medicine more slowly or more rapidly than expected. Such differences can affect drug concentration, treatment effectiveness, and the possibility of adverse reactions. For example, CYP2C19 genetic variation can influence the activation of clopidogrel, an antiplatelet medicine used in cardiovascular care. Pharmacogenomic information may therefore help clinicians consider whether a particular medication is appropriate for an individual patient. However, genetic results must be interpreted according to established clinical guidelines rather than used independently of other medical information.Precision medicine and pharmacogenomics have important applications in cancer treatment. Cancer is a complex disease involving genetic and molecular changes that can differ between patients, even when the disease originates in the same organ. Molecular testing can identify specific alterations in cancer cells

that may help determine whether targeted therapies are suitable. In addition, inherited genetic variations can influence the safety and metabolism of certain medicines used in cancer treatment. Pharmacogenomic testing may help identify patients who require particular attention when receiving selected chemotherapy drugs. These approaches can support more informed treatment decisions and may reduce avoidable medication-related toxicity. Shaaban and Ji (2024) highlight the importance of equitable pharmacogenomic implementation in oncology, noting that genetic research and clinical applications must adequately represent diverse ancestry groups to avoid unequal benefits from personalized treatment.Another important application of pharmacogenomics is found in mental healthcare. Patients receiving medicines for depression, anxiety, and other psychiatric conditions may experience different therapeutic responses and side effects. Genetic variations affecting drug metabolism can contribute to differences in medication exposure and treatment tolerability. Pharmacogenomic information may help clinicians evaluate certain medication options when treatment response is inadequate or adverse effects are experienced. Nevertheless, psychiatric treatment is influenced by many factors beyond genetics, including the patient's medical history, psychological condition, other medications, and individual treatment preferences. Donnelly et al. (2024) emphasize that genetic test results should be interpreted carefully and applied through established clinical recommendations. This is particularly important because not every genetic marker included in a commercial testing panel has sufficient evidence to guide prescribing decisions.Precision medicine also has implications for cardiovascular healthcare, infectious disease treatment, and the management of chronic conditions. Genetic information can help identify patients who may require specific medication adjustments or alternative treatment options. In cardiovascular medicine, selected pharmacogenomic associations may influence the use of antiplatelet medicines and anticoagulants. In infectious disease treatment, genetic differences can affect the metabolism of certain medicines, making pharmacogenomic information relevant in selected clinical situations. For patients receiving long-term treatment, individualized medication selection may help healthcare professionals consider differences in drug response and safety. However, pharmacogenomic testing is not necessary for every medicine or every patient. Its value depends on whether reliable evidence supports a clinically meaningful relationship between a particular genetic variation and a treatment decision.

Clinical decision-making is a central part of the precision medicine process. Healthcare professionals must interpret genetic results, understand their clinical relevance, and combine them with other patient-specific information before recommending treatment. Clinical decision support systems can help by presenting relevant genetic information, identifying important gene-drug interactions, and providing recommendations based on updated clinical guidelines. Johnson et al. (2024) reviewed genetically guided precision medicine decision support tools and identified the importance of computer-based systems in translating genetic information into patient-specific recommendations. These systems can support healthcare professionals at the point of care, but their accuracy depends on reliable genetic data, appropriate interpretation, and integration with clinical workflows.Despite its potential, precision medicine faces several

challenges that affect its wider implementation. Genetic testing can be expensive, and advanced laboratory facilities may not be available in all healthcare systems. Healthcare professionals may also lack sufficient education and training to interpret genetic reports and apply them correctly. In addition, concerns regarding genetic privacy, informed consent, data ownership, and potential discrimination require appropriate ethical and legal protections. Mai et al. (2024), in their scoping review of pharmacogenomic testing in primary care, identified financial limitations, insufficient professional training, patient awareness, and ethical and legal considerations as important barriers to implementation. These challenges demonstrate that scientific progress alone cannot guarantee successful clinical adoption.Equitable access is another important consideration in the development of precision medicine. Many genomic studies have historically included populations that do not adequately represent the genetic diversity of the global population. As a result, some genetic variants may be less thoroughly studied in particular ancestry groups, potentially affecting the accuracy and usefulness of certain tests. This problem is particularly important for countries with diverse populations and limited genomic research infrastructure. Evans et al. (2024) warn that precision medicine may increase existing healthcare inequalities if its benefits are accessible mainly to populations with greater financial and technological resources. Therefore, broader representation in genetic research, affordable testing, and appropriate national healthcare policies are essential for ensuring that personalized treatment benefits different communities.This research examines how precision medicine and pharmacogenomics are transforming personalized treatment and clinical decision-making. It focuses on the scientific principles of genetic variation, the role of pharmacogenomic testing, and its applications in different medical specialties. It also explores the contribution of clinical decision support systems and the challenges associated with implementing genomic technologies in routine healthcare. The study emphasizes that precision medicine should combine genetic information with comprehensive clinical assessment rather than rely on genetic testing alone. Its successful development requires collaboration among physicians, pharmacists, genetic researchers, laboratory specialists, healthcare institutions, policymakers, and patients.

## RESEARCH OBJECTIVES

1. To examine the principles and importance of precision medicine and pharmacogenomics in developing individualized treatment approaches.
2. To analyze the role of genetic information in medication selection, drug safety, and clinical decision-making.
3. To identify the major challenges and future opportunities associated with the implementation of precision medicine in modern healthcare.

## RESEARCH QUESTIONS

1. How do precision medicine and pharmacogenomics contribute to the development of personalized treatment strategies?

2. How can genetic information improve medication selection, reduce adverse drug reactions, and support clinical decision-making?
3. What scientific, financial, ethical, and technological challenges affect the implementation of precision medicine in healthcare systems?

## LITERATURE REVIEW

Precision medicine has become an important area of contemporary medical research because of its potential to improve the effectiveness and safety of healthcare interventions. Existing literature describes precision medicine as an approach that uses individual biological, genetic, environmental, and lifestyle information to guide disease prevention, diagnosis, and treatment. It recognizes that patients with similar medical conditions may have different underlying biological characteristics and may therefore respond differently to the same treatment. Advances in genomic sequencing, molecular diagnostics, data analysis, and artificial intelligence have expanded the possibilities of identifying patient-specific characteristics. Evans et al. (2024) explain that precision medicine brings together genomic technologies and data-driven approaches to support individualized healthcare. Their review also emphasizes the importance of evaluating real-world effectiveness, affordability, and the possibility of increasing healthcare inequalities.Pharmacogenomics is a major component of precision medicine that focuses specifically on the influence of genetic variation on drug response. Research in this field has identified relationships between particular genes and the effectiveness, metabolism, or safety of selected medicines. Genetic variations can influence drug-metabolizing enzymes, transport proteins, and drug targets, resulting in differences in treatment outcomes. Pharmacogenomic testing can help identify selected variants and provide information that may support medication selection or dosage decisions. Donnelly et al. (2024) discuss how pharmacists can interpret pharmacogenomic reports and apply clinically relevant genetic information to patient care. Their work emphasizes that genetic results should be evaluated according to established clinical guidelines and considered alongside other patient-specific factors.The implementation of pharmacogenomics in clinical practice has received increasing attention because of its potential to improve medication safety. Adverse drug reactions and treatment failures can result from several factors, including inappropriate drug selection, incorrect dosage, drug interactions, and individual differences in metabolism. Pharmacogenomic information may help identify selected patients who are at increased risk of specific medication-related complications or who may require alternative treatment approaches. However, the usefulness of testing depends on the strength of evidence connecting a particular gene-drug pair with a clinically meaningful outcome. Polasek (2024) critically examines the role of pharmacogenomics in clinical medicine and highlights the need to distinguish between genetic associations that have practical prescribing implications and those that do not yet justify changes in treatment.

Clinical practice guidelines are essential for translating pharmacogenomic discoveries into reliable medical decisions. The Clinical Pharmacogenetics Implementation Consortium develops

evidence-based guidelines that explain how available genetic test results can be used to optimize drug therapy. These guidelines provide information about the relationship between genotypes, predicted metabolic phenotypes, and recommended prescribing actions for selected gene-drug pairs. They are intended to help clinicians interpret genetic information when results are available, rather than determine whether every patient should undergo testing. Donnelly et al. (2024) emphasize the importance of using updated guidelines to assess the actionability of genetic results and avoid inappropriate medication changes. This evidence-based approach is important because genetic testing panels may include markers for which clinical recommendations remain uncertain.The role of digital technologies in precision medicine has also become an important research area. Clinical decision support systems can connect genetic test results with electronic health records and provide patient-specific recommendations to healthcare professionals. These systems may identify relevant gene-drug interactions, display prescribing guidance, and support decisions at the point of care. Johnson et al. (2024) conducted a systematic review of genetically guided precision medicine clinical decision support tools. Their research examined implemented systems designed to provide genetic risk assessments and treatment recommendations to patients and healthcare providers. The review demonstrates that digital decision support can help translate complex genetic information into practical clinical guidance, although successful implementation requires reliable data, appropriate system design, and integration into existing healthcare workflows.

Farmaki et al. (2024) examined the relationship between precision medicine, digital health, and pharmacogenomic clinical decision support systems. Their systematic review identified 19 pharmacogenomic decision support systems across 29 relevant publications. The authors highlighted the potential of digital tools to facilitate the integration of pharmacogenomic information into routine clinical practice. Their findings also indicated that many initiatives were concentrated in the United States, demonstrating the need for broader implementation efforts in other regions. This research is important because pharmacogenomic knowledge can be difficult to apply consistently without accessible clinical guidance. Digital systems may support healthcare professionals by providing relevant recommendations, but they require regular updates, technical maintenance, and appropriate clinical validation.The integration of pharmacogenomic testing into primary healthcare has also been investigated. Mai et al. (2024) conducted a scoping review examining the enablers and challenges of implementing pharmacogenomic testing in primary care settings. Their review included 78 studies and identified several potential benefits, including therapeutic improvements, medication safety, cost-related advantages, and greater support for healthcare professionals. However, the authors also identified barriers such as insufficient scientific evidence for some applications, limited professional training, ethical and legal concerns, low patient awareness, and the high costs of testing. Their findings demonstrate that successful implementation requires more than laboratory availability. Healthcare professionals need appropriate education, patients require understandable information, and health systems must establish sustainable arrangements for testing and

interpretation.

Precision medicine has also become increasingly relevant to cancer treatment. Molecular testing can identify specific characteristics of tumors that may influence the selection of targeted therapies. Pharmacogenomic testing can provide additional information about inherited genetic variations that influence the safety and metabolism of certain anticancer medicines. Shaaban and Ji (2024) discuss the importance of equitable pharmacogenomic testing in oncology and identify concerns about the underrepresentation of some ancestry groups in genetic research. Their analysis highlights the possibility that differences in research representation may affect the availability and accuracy of pharmacogenomic information for diverse populations. This literature indicates that precision medicine should be developed through inclusive research practices to ensure that its clinical benefits are not restricted to a limited group of patients.Ethical and practical considerations remain central to the future development of precision medicine. Genetic information is highly personal and may reveal details relevant to patients and their biological relatives. Its collection, storage, interpretation, and sharing therefore require appropriate privacy protections and informed consent procedures. Healthcare institutions must also ensure that genetic results are interpreted accurately and are not used to make unsupported assumptions about an individual's health or treatment needs. Evans et al. (2024) emphasize the importance of considering affordability, data management, and healthcare inequalities when expanding precision medicine into routine care. Overall, the literature demonstrates that precision medicine and pharmacogenomics can support individualized treatment and clinical decision-making, but their successful application depends on scientific evidence, professional expertise, ethical governance, and equitable access to healthcare technologies.

## METHODOLOGY

This research adopts a qualitative and descriptive methodology based on secondary data collected from peer-reviewed academic publications, systematic reviews, clinical guidelines, and relevant scientific literature. The study examines precision medicine and pharmacogenomics as developing approaches in modern healthcare, focusing on their scientific foundations, clinical applications, and influence on personalized treatment decisions. Published research concerning genetic variation, drug metabolism, pharmacogenomic testing, clinical decision support systems, and implementation challenges was considered to develop a comprehensive understanding of the topic. Particular attention was given to recent literature discussing the integration of genetic information into routine clinical practice.The research focuses on several major areas, including the relationship between genetic variations and drug response, the role of pharmacogenomic testing in medication selection, and the use of genetic information in clinical decision-making. It also examines applications in oncology, cardiovascular medicine, mental healthcare, and the management of chronic conditions. The study considers the contribution of clinical practice guidelines and digital decision support systems in helping healthcare professionals interpret genetic results. In addition, it investigates challenges associated with testing costs, laboratory

infrastructure, professional education, patient awareness, genetic privacy, and unequal representation in genomic research.A thematic approach was used to organize and interpret the information obtained from the reviewed sources. Relevant findings were grouped into major themes, including the principles of precision medicine, pharmacogenomic applications, clinical decision support, patient safety, ethical considerations, and implementation barriers. Information from different publications was compared to identify common findings and areas requiring further investigation. Clinical guidelines were considered to understand how genetic results can be translated into evidence-based prescribing recommendations. The research does not involve original patient recruitment, clinical trials, or laboratory testing. Instead, it provides an analytical review of existing evidence to examine the contribution of precision medicine and pharmacogenomics to modern healthcare.

## RESEARCH DESIGN

The study follows a descriptive and analytical research design to investigate the relationship between precision medicine, pharmacogenomics, and personalized clinical decision-making. The descriptive component explains the scientific concepts underlying individualized healthcare and examines how genetic variations influence the response to selected medicines. It also describes the major technologies used in precision medicine, including genetic testing, molecular diagnostics, genomic analysis, and clinical decision support systems. The analytical component evaluates how this information may influence treatment selection, dosage decisions, medication safety, and patient outcomes.The research design is based on the review and comparison of existing scientific evidence rather than primary clinical data collection. Academic studies, systematic reviews, clinical recommendations, and professional guidance documents were examined according to their relevance to the research objectives. Particular attention was given to studies that investigated the practical implementation of pharmacogenomic testing and genetically guided decision support systems. The study also considers the limitations of genetic testing, including incomplete variant coverage, differences in genetic diversity, and the need to interpret results alongside other clinical information.The study further uses a patient-centered healthcare perspective to evaluate the practical value of precision medicine. It considers how individualized treatment decisions may support patient safety, medication effectiveness, and the appropriate use of healthcare resources. At the same time, it examines the importance of affordability, privacy protection, professional training, and equitable access. This design provides a framework for understanding both the opportunities and limitations of precision medicine and for identifying strategies that can support its responsible integration into modern healthcare systems.

## DATA ANALYSIS

The reviewed literature indicates that genetic variation can influence the way individuals respond to particular medicines. Differences in genes responsible for drug metabolism, transport, and

drug-target activity may affect medication effectiveness and the risk of adverse reactions. Pharmacogenomic testing can identify selected variants that are relevant to specific treatments and may help clinicians consider alternative medicines or dosage adjustments. However, the relationship between a genetic variant and a treatment outcome must be supported by reliable clinical evidence. The analysis therefore indicates that pharmacogenomics is most useful when genetic information is connected to established gene-drug recommendations rather than interpreted as a general prediction of treatment success.The analysis also demonstrates that precision medicine can support clinical decision-making through the integration of genetic information with other patient-specific characteristics. Age, kidney function, liver function, medical history, concurrent medicines, and lifestyle factors may influence treatment decisions alongside genetic information. Donnelly et al. (2024) emphasize that pharmacogenomic results should not be used independently when developing a treatment plan. Clinical decision support systems can assist healthcare professionals by organizing relevant genetic information and presenting evidence-based recommendations. Johnson et al. (2024) and Farmaki et al. (2024) highlight the potential of these digital tools to support the practical application of genetically guided precision medicine.

The analysis identifies several barriers that may limit the wider use of precision medicine. Genetic testing and advanced laboratory services may be expensive, while many healthcare institutions lack the infrastructure and trained professionals required to interpret complex genetic information. Patients may also have concerns about the privacy and future use of their genetic data. Mai et al. (2024) identified financial limitations, professional training requirements, ethical and legal concerns, and low patient awareness as important challenges to the implementation of pharmacogenomic testing in primary care. These findings indicate that successful implementation requires investment in education, laboratory capacity, data protection, and sustainable healthcare policies.The analysis further highlights the importance of genetic diversity and equitable access. Genetic variants may occur at different frequencies across populations, and testing panels that do not adequately represent this diversity may fail to identify clinically important variants in some individuals. This can affect the accuracy and usefulness of genetic interpretation. Shaaban and Ji (2024) emphasize the need for inclusive research and equitable pharmacogenomic implementation, particularly in oncology. The overall analysis suggests that precision medicine can improve personalized treatment when supported by reliable evidence, updated clinical guidelines, trained professionals, and inclusive research practices. Its effectiveness also depends on combining genomic information with comprehensive clinical assessment and ensuring that the benefits of technological development are accessible to diverse populations.

**FINDINGS**

The study finds that precision medicine represents an important development in modern healthcare because it recognizes individual differences in genetic, biological, environmental, and

lifestyle characteristics. These differences can influence disease development and treatment response, making individualized approaches valuable in selected clinical situations. Pharmacogenomics contributes to this development by examining how genetic variations affect medication metabolism, effectiveness, and safety. The findings indicate that genetic information can support more informed medication decisions when reliable evidence connects a particular genetic variant with a specific drug response.The research also finds that pharmacogenomic testing has important applications in several medical specialties, including oncology, cardiovascular medicine, mental healthcare, and the management of chronic conditions. Genetic information may help identify patients who require particular medication considerations or alternative treatment options. However, the usefulness of testing varies according to the medicine, the clinical condition, and the strength of available evidence. Genetic results should therefore be interpreted alongside age, kidney and liver function, medical history, other medicines, and relevant clinical guidelines. Pharmacogenomics should support professional judgment rather than replace comprehensive medical assessment.

Another major finding is that clinical decision support systems can help translate complex genetic information into practical treatment recommendations. These systems may connect genetic test results with electronic health records and provide guidance about selected gene-drug interactions. However, their effectiveness depends on accurate data, updated guidelines, appropriate software design, and integration into clinical workflows. The study also finds that insufficient professional training and limited patient awareness can restrict the practical use of pharmacogenomic information. Healthcare institutions therefore need to strengthen professional education and develop clear communication strategies for explaining genetic test results to patients.Finally, the study finds that the implementation of precision medicine faces significant financial, technological, ethical, and social challenges. High testing costs, limited laboratory facilities, privacy concerns, and unequal representation in genomic research may restrict access to its benefits. The findings emphasize that precision medicine must be developed through inclusive research, affordable testing strategies, strong data protection, and equitable healthcare policies. Further research is needed to evaluate the long-term clinical effectiveness and cost-effectiveness of pharmacogenomic interventions across different populations and healthcare systems. These findings suggest that precision medicine can contribute to improved treatment decisions when scientific innovation is combined with ethical responsibility and practical healthcare planning.

## CONCLUSION

Precision medicine and pharmacogenomics are transforming modern healthcare by supporting treatment decisions based on the individual characteristics of patients. Genetic variations can influence medication metabolism, therapeutic response, and the risk of adverse drug reactions. By identifying selected genetic differences, pharmacogenomic testing can provide valuable information for medication selection and dosage decisions. Its applications in oncology,

cardiovascular medicine, mental healthcare, and other medical fields demonstrate its potential to support safer and more individualized treatment. The findings of this research indicate that precision medicine can strengthen clinical decision-making when genetic information is interpreted according to reliable scientific evidence and established clinical recommendations.

The study concludes that pharmacogenomics should be integrated into clinical practice through a coordinated approach involving physicians, pharmacists, genetic specialists, laboratory professionals, and healthcare institutions. Clinical decision support systems can help translate genetic information into practical recommendations, while updated guidelines can support consistent interpretation and appropriate prescribing. However, genetic results must always be considered alongside other patient characteristics, including age, organ function, medical history, and concurrent medication use. Precision medicine should therefore complement comprehensive clinical assessment rather than replace professional judgment.The research also concludes that several barriers must be addressed before the benefits of precision medicine can become widely available. High testing costs, limited laboratory infrastructure, insufficient professional training, data privacy concerns, and unequal representation in genomic research can restrict its implementation. Governments and healthcare organizations should develop policies that support affordable genetic testing, professional education, secure data management, and inclusive research. Particular attention should be given to populations that remain underrepresented in genomic studies to ensure that genetic testing and clinical recommendations are appropriate for diverse communities.Ultimately, precision medicine and pharmacogenomics offer important opportunities to improve treatment selection, medication safety, and patient-centered healthcare. Their future success will depend on the responsible integration of scientific evidence, digital technologies, clinical expertise, and ethical standards. Continued research is required to establish the clinical value and cost-effectiveness of different pharmacogenomic applications and to improve access across healthcare systems. A balanced and evidence-based approach can help transform personalized treatment from a specialized medical service into a more accessible component of modern clinical practice.

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