Ethical Considerations in the Implementation of Precision Personalized Medicine

Andrew Dickens[1], Dino Prato[2], Shamsuddin Sultan Khan[3*]

Abstract

Governments are increasingly investing in precision medicine (PM) to improve healthcare outcomes by utilizing data analytics and genomic analysis to develop individualized treatment plans. The success of PM relies heavily on clear public messaging that fosters trust and secures the social license to collect and exchange large population-wide datasets. However, the diverse terminologies used across various programs can complicate communication and undermine confidence in these efforts. Language plays a pivotal role in shaping expectations and creating a shared understanding of PM among participants, healthcare providers, and researchers. Personalized medicine, which emerged a decade ago, aims to prescribe the right medication to the right patient based on genetic information. While the medical field is evolving, the shift toward individualized care raises complex ethical challenges that require careful consideration. This review categorizes and examines the ethical issues surrounding PM, particularly in research, development, and service delivery. Our analysis highlights several critical ethical concerns, including healthcare service availability, informed consent, knowledge gaps, privacy, and confidentiality. Moreover, it is crucial to balance the benefits of advancing research and individual health improvements with societal good. As such, an ethical framework with clear rules and norms is essential, alongside ongoing, personalized ethical decision-making to ensure the responsible development and application of precision medicine.

Keywords: Ethics, Personalized medicine, Pharmacogenetics studies, Genetic data.

Significance | This review emphasizes the ethical challenges in precision medicine, highlighting the need for clear frameworks, informed consent, and equitable access.

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1. Introduction

The concept of "personalized medicine," or "precision medicine," emerged in academic discourse over a decade ago and has rapidly evolved since then. This approach to healthcare refers to a novel strategy for treatment and prevention that considers the genetic and behavioral heterogeneity of each individual (Abettan et al.,2016). While terms like genomic medicine and precision medicine are often used interchangeably, they are not identical. The swift rise of personalized medicine correlates with significant advancements in genetic research, particularly the completion of the Human Genome Project. Personalized medicine shifts away from the traditional "one size fits all" model of healthcare to a more tailored approach where the "right drug" is administered to the right patient at the right time (Adams et al.,2016). According to this approach, an individual's genetic makeup plays a pivotal role in determining their response to medications, foods, and lifestyle choices. Personalized medicine, therefore, focuses on utilizing genetic variations among individuals to aid in diagnosing, preventing, and treating medical conditions (Ahmed et al.,2014).

At the core of personalized therapy lies pharmacogenomics, the study of how genes affect a person's response to drugs, which is

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foundational to the personalized medicine model (Badzek et al.,20132). These advancements have empowered the medical field to identify disorders at the molecular level, unlocking new possibilities for more accurate diagnoses and targeted treatments. In this redefined approach to medicine, genetic information is not only considered for individual treatment plans but is also applied to public health. Personalized medicine promises several advantages: more precise diagnostic assessments, leading to earlier and more effective treatment interventions; enhanced drug efficacy and reduced side effects; and the identification of genetic predispositions, paving the way for preventative healthcare strategies (Barry et al.,2012).

Despite its potential, personalized healthcare remains a contentious subject, with diverse perspectives on its feasibility and impact. Some proponents view personalized medicine as a revolutionary shift in healthcare that could significantly improve patient outcomes (Beskow et al.,2010) and prove to be effective in clinical settings. However, others argue that it is an impractical approach that lacks sufficient empirical backing. Additionally, bioethicists emphasize the need for further analysis, particularly in terms of individualism and ethical theory, as these areas pose significant challenges in the twenty-first century (Breton et al.,2021).

Personalized medicine, which heavily relies on genetic information and its translation into clinical practice, has introduced new ethical dilemmas. Among these, (Brothers et al.,2015) have highlighted four key aspects of genomic testing—analytical validity, clinical validity, clinical utility, and non-targeted testing—that raise ethical, legal, and sociological issues (ELSI). (Bunnik et al.,2011) posits that while industry professionals and scientists may be overly optimistic about the potential of personalized medicine, bioethicists, anthropologists, social scientists, and lawyers may also be equally misguided in generating hype without considering the broader societal implications. This unbridled optimism, according to Hansson, could potentially lead to the premature decline of personalized medicine.

The ethical challenges surrounding personalized medicine are fluid and complex, as emphasized by (Chiapperino et al.,2016), with significant concerns regarding the dynamics of the doctor-patient relationship, as well as research and development practices. (Cordeiro et al.,2014) suggest that personalized medicine could lead to more effective health promotion, individualized diagnosis, and patient empowerment. However, these benefits are contingent upon overcoming scientific and technological barriers while considering the ethical and social consequences of personalized medicine.

As personalized medicine continues to encounter these ethical challenges, many critical issues remain unresolved. Without addressing these ethical considerations, the development and refinement of personalized treatments will be stymied. To address this, we review the anticipated ethical concerns surrounding personalized medicine in the realms of healthcare delivery and research and development. This analysis explores the ethical dimensions of personalized medicine from multiple perspectives, including the doctor-patient relationship and the broader implications for research and development, as summarized in Table 1. Through this examination, we aim to shed light on the moral dilemmas that need to be addressed to ensure the responsible advancement of personalized medicine.

2. Research and Development in Personalized Medicine: A Focus on Pharmacogenetics

Research and development in personalized medicine are deeply intertwined with genetic science, which provides the foundation for shifting from traditional medicine to more individualized approaches. One of the key areas of focus within personalized medicine is pharmacogenetics, which seeks to tailor drug treatments based on an individual's genetic makeup. The primary goal of pharmacogenetics is to minimize the risk of adverse drug reactions and optimize therapeutic efficacy (De Vries et al.,2011). However, while this field holds significant promise, its impact and the ability to truly personalize treatments remain debatable.

A major benefit of pharmacogenetics is the potential to develop safer and more effective medications. By understanding how an individual's genetic variations affect drug metabolism and response, healthcare providers can prescribe medications that are more likely to be effective and less likely to cause harmful side effects. However, the cost-effectiveness of pharmacogenetics remains a topic of discussion. Pharmaceuticals contribute only a small percentage to overall healthcare costs, and while pharmacogenetics could reduce the financial burden of side effects, its overall impact on healthcare expenses is still uncertain (Evans et al.,2012). Despite these challenges, pharmacogenetics is regarded as a viable method for reducing the risks associated with drug side effects, although the magnitude of its impact may be limited due to the complex interplay of genetic and environmental factors (Fasanelli et al.,2015)

3. Risk/Benefit Assessment in Pharmacogenetics Studies

The development of individualized medicine, particularly in the context of genetic investigations, requires careful evaluation of the risks and benefits. Genetic testing for pharmacogenetics presents an ethical dilemma: the benefits to individual patients must be weighed against the broader benefits to society. Research ethics aims to strike a balance between the interests of individuals and those of the public health community. For instance, genetic testing might benefit individuals by providing personalized treatment plans, but its broader implications for public health and individual rights remain contentious. The debate centers around whether genetic

testing infringes on personal rights in favor of public health objectives, with public health ethics providing justification for such trade-offs (Figure 1, Table 2).

In the context of pharmacogenomics, (Garcia et al.,2019) caution against creating a healthcare divide where less-developed nations are excluded from the advantages of personalized medicine. They argue that personalized medicine should not be implemented in a "boutique-style" healthcare system that primarily benefits wealthier populations. Instead, the benefits of genetic testing and personalized treatments should be equitably distributed to ensure that all populations, including those in developing nations, can access the advancements of personalized medicine.

Pharmacogenetics can aid in selecting individuals who are more likely to benefit from or experience adverse reactions to specific medications. This enables more precise patient cohort selection for clinical trials, which can streamline the process of conducting studies, reducing both costs and time (Green et al.,2011). Additionally, pharmacogenetics allows for better evaluation of the safety profile of pharmaceuticals on the market. However, while these benefits are significant, challenges remain, particularly regarding the costs associated with gene-based treatments and genetic testing. (Green et al.,2013) note that the high expenses involved in gene-based therapies present a significant barrier to the widespread adoption of pharmacogenetics in healthcare.

A key issue is that many Phase III clinical trials are conducted in underdeveloped countries, where the costs of novel medications are often prohibitive. Some proponents of personalized medicine argue that specific personalized medicine approaches may not require the traditional phases of clinical trials. These approaches are based on the assumption that established mechanisms of action can sufficiently prove the efficacy of personalized treatments (Hansson et al,2010). In this context, researchers hope to reduce both time and costs by employing alternative study designs. Nevertheless, (Joly et al.,2013) emphasize that pharmacogenetics studies may not offer direct benefits to research participants compared to standard clinical drug trials, which complicates their implementation in practice.

4. The Ethical Implications of Genetic Testing

The clinical validity and potential risks of genetic testing remain a subject of significant debate. Personalized medicine relies on genetic research to assess genetic characteristics within populations, but this practice can have harmful consequences for certain racial or ethnic groups. For example, an analysis of the Maori people, an indigenous group in New Zealand, linked a hereditary trait to an increased likelihood of violent crime. This study was later revealed to be scientifically flawed and misleading, but it caused significant harm to the Maori community by perpetuating stereotypes and fostering stigmatization (Joly et al.,2014). This case highlights the risks of misinterpreting genetic data and the ethical dangers of relying too heavily on genetic research without considering its potential social consequences.

In conclusion, while pharmacogenetics holds considerable promise for improving personalized medicine, significant challenges remain, both in terms of its scientific validity and its ethical implications. Research and development in this field must continue to address the technical, financial, and societal barriers that impede its widespread implementation. As personalized medicine progresses, it is crucial to maintain a focus on the ethical considerations surrounding genetic testing, ensuring that the benefits of these advancements are realized in a fair and equitable manner.

5. Subject Selection and Ethical Considerations in Pharmacogenetics and Personalized Medicine

The application of pharmacogenetics in subject selection for clinical trials represents a pivotal step in reducing risks and maximizing the value of such studies. By using genetic information to identify individuals most likely to benefit from specific treatments, researchers can focus on a smaller, more targeted population. This approach ensures that the number of patients exposed to research risks is limited, promoting fairness in clinical trials. Through such selective participant recruitment, those who stand to gain the most from the study are prioritized, enhancing both the ethical integrity and potential impact of the research (Joly et al.,2016). However, practical concerns arise when the appeal of larger patient groups—offering greater financial incentives to participants—undermines the value of smaller, more specific groups or orphan populations (Juengst et al.,2012).

Despite these benefits, the use of pharmacogenetics in clinical trials is not without challenges. A superficial understanding of pharmacogenomics and the application of genetically defined races in research may lead to inappropriate or inadequate care. Furthermore, this approach can exacerbate healthcare disparities, particularly in underrepresented populations (Kittles et al.,2012). Pharmaceutical companies, driven by profit motives, may be less inclined to develop drugs aimed at small populations, especially when the associated market share is limited. This underscores the need for equitable access to personalized medicine across diverse racial, ethnic, and socioeconomic groups.

For personalized medicine to become a widespread practice, it is crucial to include genetic data from all racial and ethnic groups in research. However, historically marginalized and impoverished populations are often excluded from genetic studies, limiting the benefits of tailored therapies for these groups (Knoppers et al.,2010). As a result, disparities in healthcare access and outcomes could persist or even widen. Moreover, countries with wealthier healthcare systems may not experience the same health issues that

drive morbidity and mortality in poorer nations. Therefore, for personalized medicine to succeed in developing countries, research must focus on populations that have been underrepresented in medical studies to date (Langanke et al.,2011).

6. The Role of Biobanks in Personalized Medicine

The rise of genomic information-based personalized medicine has led to the establishment of biobanks worldwide, which store biological samples used in genetic research. The expansion of these biobanks raises significant ethical concerns regarding the collection, storage, use, and sharing of samples. In particular, issues surrounding informed consent, sample identity, privacy, re-identification, and global sample sharing have become focal points for ethical debate (Maglo et al.,2012). Biobanks offer valuable resources for advancing personalized medicine by providing a repository of genetic material for research, but the handling of these samples necessitates stringent ethical guidelines to ensure participants' rights are protected.

7. Informed Consent in Personalized Medicine

Informed consent is a cornerstone of ethical practice in personalized medicine. For patients to make fully informed decisions about participating in genetic studies and clinical trials, they must possess comprehensive knowledge of the potential risks, benefits, and implications of their involvement. The relationship between physician and patient plays a critical role in this process, as personalized treatment decisions require greater communication, understanding, and mutual decision-making (Meslin et al.,2010). Because individualized therapy is influenced by the values and preferences of the patient, it requires a higher level of literacy and understanding compared to traditional medical approaches (Nelson et al.,2011).

Given the complexity of genetic testing and the evolving nature of genetic research, the traditional model of informed consent may be insufficient. Researchers and clinicians must consider dynamic models of consent, which allow for ongoing communication between participants and researchers throughout the course of the study (Ormond et al.,2014). Some experts advocate for adopting a public health approach to informed consent, which prioritizes the broader societal benefits of personalized medicine while also respecting individual autonomy (Ormond et al.,2014).

Misinterpretation of genetic research or the uncertainty surrounding test results can complicate the informed consent process. Patients may not fully grasp the implications of genetic testing, and the complexity of genetic data may obscure the risks and potential outcomes (Page et al.,2021). As a result, informed consent procedures must be clear, concise, and tailored to the needs of the patient, ensuring they understand both the individual and societal benefits of participating in pharmacogenetics studies.

For pharmacogenetics studies, specific consent forms should address genetic research, including the use of genetic testing relevant to drug effects and broader pharmacogenetic studies. In particular, patients must be made aware of the risks of exploitation, especially when personal and familial information is shared for genetic research purposes (Petersen et a.l,2014). Financial remuneration for participation in pharmacogenetics studies also presents ethical concerns, as these studies often involve non-therapeutic sample collection, raising questions about coercion and undue inducement (Pratt et al.,2019).

8. Challenges in Informed Consent for Biobanks

In biobanks, the issue of informed consent is even more complex. Not only must participants be informed about the collection and use of their biological samples, but they must also understand the long-term storage, potential future use, and possible re-identification of their samples. The process of obtaining informed consent for biobank participation should include details about sample anonymity, storage, usage, and destruction, as well as procedures for withdrawing consent and returning research findings, including any unintended or incidental findings (Rosenberg et al.,2010).

Biobanks that operate across national and international borders face additional challenges in ensuring that their informed consent processes adhere to global ethical norms. Variations in legal systems and scientific objectives can result in discrepancies in consent procedures, such as opt-in or opt-out mechanisms (Rotimi et al.,2010). Therefore, biobanks must implement flexible and transparent informed consent practices that respect both local legal frameworks and international standards for ethical research (Sacristán et al.,2013).

As personalized medicine and pharmacogenetics continue to evolve, the ethical challenges associated with subject selection, biobanks, and informed consent will remain central to the discussion. While pharmacogenetics holds promise for more effective, personalized treatments, the equitable inclusion of diverse populations, protection of patient autonomy, and transparency in the use of genetic data are essential to ensuring the responsible advancement of this field. Researchers, clinicians, and policymakers must work together to address these ethical concerns and ensure that personalized medicine benefits all populations, not just those who are historically well-represented in medical research.

9. Data Availability, Confidentiality, and Discrimination in Personalized Medicine

The availability of genetic data is a key factor in the development of personalized medicine, which holds the promise of more effective and individualized healthcare. According to the Iranian National Ethical Guideline for Genetic Research, "the results of research on

the human genome should be accessible for society" (Salari e al.,2017). However, the ownership and accessibility of genetic data remain contentious issues that have implications for the future of personalized medicine. While the notion of making genotype-phenotype associations publicly accessible is critical for advancing customized treatment, the reality is that many hospitals and laboratories store their genetic data in proprietary databases, restricting access. This raises concerns about the ethical implications of data withholding, particularly in light of the patient's role in owning their genetic information and the public funding often involved in genetic research. Conversely, the sharing of genetic data brings forward significant concerns about patient confidentiality and privacy (Schaefer et al.,2019).

9.1 Confidentiality of Genetic Data

Genetic data are considered exceptionally sensitive because they provide insight not only into an individual's health but also into the health risks for their family members and future generations. Unlike other forms of health data, genetic information has the unique potential to affect one's identity and social standing. As such, healthcare providers are ethically obligated to protect the privacy and confidentiality of this information. (Schleidgen et al.,2013) outline three main reasons why protecting the secrecy of genetic data is vital: first, the release of private genetic information can lead to stigmatization and discrimination; second, inaccurate disclosure can compromise the quality of healthcare by causing emotional distress or misguided decisions; and third, breaches of privacy can have public health consequences by delaying treatment or preventing people from seeking care due to fear of their genetic data being exposed.

The rise of electronic health records has only exacerbated concerns about privacy violations. As personalized medicine increasingly incorporates genetic data into healthcare decisions, the risk of breaches in confidentiality becomes more pronounced. Under normal circumstances, confidentiality is a strict obligation; however, this may be overridden if there is an immediate threat to the health of a third party, such as when family members are at risk due to hereditary conditions. While it is essential for healthcare providers to respect patients' confidentiality, there is also a moral obligation to inform family members about potential hereditary diseases, especially when there is a possibility of a significant genetic predisposition (Stein et al.,2013).

Furthermore, genetic data can be valuable to employers and insurance companies, raising concerns about discrimination. (Stunnenberg et al.,2016) warn that personalized medicine may undermine public trust in healthcare systems if confidentiality is not rigorously protected. The balance between society's interests in using genetic data for public health benefits and an individual's right to privacy is a complex ethical dilemma. (Suldovsky et al.,2016) suggest that while personalized medicine may improve health outcomes, careful consideration must be given to how genetic information is shared and used in societal contexts. The concept of genetic exceptionalism further underscores the need for special protections for genetic data. Genetic exceptionalism argues that genetic information is unlike other data due to its predictive power, the stability of the information over an individual's lifetime, and its potential to reveal future health risks. In this context, the issue arises of whether a family member should have the right to know about genetic risks, even if it compromises the patient's confidentiality (Tajdar et al.,2021). While some argue for the absolute protection of privacy, others, like (Timmermans et al.,2010), believe that complete privacy is not feasible in direct-to-consumer genetic testing, suggesting that genetic data must be handled with the same care as any other personal information.

9.2 Genetic Discrimination in Personalized Medicine

Genetic discrimination is another significant ethical concern that arises with the use of genetic data in personalized medicine (Figure 2). As the human genome project and subsequent genetic research have made genetic information more accessible, the potential for discrimination based on genetic data has become a real threat (Wagner et al.,2014). Personalized medicine, which often involves analyzing minute genetic variations, could exacerbate existing inequalities and lead to discrimination in healthcare, insurance, and employment. For instance, employers or insurance companies may use genetic data to make decisions about hiring, coverage, or pricing, potentially discriminating against individuals based on their genetic predisposition to certain diseases. Moreover, the use of biobanks, which store genetic data for research, introduces the possibility of selective use of this information based on race, ethnicity, or other factors that could lead to discriminatory practices.

Despite these concerns, there is evidence suggesting that pharmacogenetics, the study of how genetic differences affect individual responses to drugs, can offer significant benefits by improving efficacy and reducing adverse drug reactions. (Walton et al.,2019) argue that genetic information, when properly utilized, does not inherently lead to systemic discrimination. Instead, they emphasize the importance of considering additional factors such as culture, environment, and socioeconomic status, which can influence both genetic predispositions and health outcomes (Wolf et al.,2013). While there is no inherent problem with using genetic data to personalize treatments, the misuse of this information in ways that lead to unfair treatment or exclusion remains a significant ethical challenge.

The ethical issues surrounding data availability, confidentiality, and discrimination in personalized medicine are complex and multifaceted. While the promise of more effective and tailored

treatments is a major benefit of personalized medicine, the use of genetic data raises significant concerns about privacy and potential misuse. Ensuring that genetic information is accessible, protected, and used in ways that respect individual rights while promoting public health benefits is essential for the responsible advancement of personalized medicine. As genetic research continues to evolve, ethical frameworks must be adapted to address the changing landscape of medical practice, ensuring that the benefits of personalized medicine are realized without compromising fundamental rights such as privacy and non-discrimination. Only through thoughtful, transparent policies can the potential of personalized medicine be fully realized in a way that benefits all individuals, regardless of their genetic makeup.

9.3 Incidental findings

Genetic testing on several family members carries the possibility of unintended results beyond the intended goals, such as non-paternity or the discovery of a gene mutation that could have detrimental effects on the health of the tested family members. It's advised to anticipate accidental results as much as possible before to testing, even while the likelihood of such findings is unpredictable and the significance of such data may not always be fully understood before facing (Wu et al.,2019). The four bioethical principles of autonomy, justice, beneficence, and non-maleficence—which are currently being debated in personalized medicine—were taken into consideration in the whole-genome analysis, which led to the recent recommendation by the American College of Medical Genetics and Genomics (ACMG) for the disclosure of incidental findings (Wynn et al.,2018). While ethicists rank autonomy as the most important of those values, ACMG ranks beneficence higher and advises against offering study participants the option of choosing whether or not to disclose incidental findings (Zhang e al.,2016). Returning incidental discoveries, according to Ormond and Cho, is crucial and need to be taken into account in accordance with patient preferences and evidence-based practices (Collins et al.,2015). As a result, it is imperative that guidelines be created pertaining to the return of genetic results and incidental findings (Ashley et al.,2015).

9.4 Service availability

Furthermore, the "availability of benefits from advances in biology, genetics, and medicine to all" is emphasized in the 1997 Universal Declaration on Human Genome and Human Rights. Therefore, even though the majority of these services are costly and not covered by insurance, everyone should have access to healthcare based on new genetic knowledge, not only those for whom it is financially feasible. For instance, gene editing is a very costly treatment for cancer that is not available to everyone or reimbursed by insurance. Another illustration is the FDA-approved medication Herceptin, which is used to treat both early-stage and advanced HER2-positive breast cancer. Although it is an expensive medication, insurance now covers it in Iran. According to DeVries et al., insurance and regulation are essential for the equitable and moral distribution of resources in order to stop inequality and safeguard marginalized groups (Evans et al.,2003). The number of people who benefit from customisation is limited by the high expense of new medications and laboratory testing.

9.5 Justice

Dorothy Wertz engaged in a minority argument regarding the expenses associated with drug development using pharmacogenetics science. Governments, business, and insurance firms disagree, he claims, when it comes to raising the costs of drug development for minorities (Wang et al.,2014). In his argument, Holm discusses resource allocation, global fairness, and the potential advantages for low- and middle-income nations. However, Hansson thinks that legislators, including governments and parliaments, should be in charge of defending individualized medicine (Desmond et al.,2015).

Less than 10% of participants at the National Human Genome Research Institute (NHGRI) were from China, Japan, or other Asian nations, according to one research (Cohen et al.,2014). Maintaining these discrepancies in fundamental research leads to unequal topic selection or study participant distribution and participation, which informs individualized medicine. The quality of health is impacted by access to a healthy diet and lifestyle, particularly among underprivileged communities, and this leads to an uneven allocation of health resources. Therefore, it's possible that the current health disparities are made worse by individualized therapy (Hall et al.,2016).

According to certain academics, in order for customized medicine to be successfully implemented, adequate focus needs to be placed on ensuring that treatments are as individually tailored as possible and that they are accessible to all qualified racial and ethnic groups. Therefore, such factors should be taken into consideration while creating research methods and allocating resources (Pal et al.,2012).

10. Incidental Findings, Service Availability, Justice, and Physician-Patient Relationship in Personalized Medicine

Personalized medicine, which aims to tailor medical treatments to an individual's genetic profile, holds great potential for enhancing healthcare. However, it also raises important ethical and practical considerations. Among these are the handling of incidental findings, the accessibility of personalized treatments, issues of justice and equity, and the impact of genetic medicine on the physician-patient relationship. These challenges must be addressed to ensure that the benefits of personalized medicine are equitably distributed and that patient rights and dignity are respected.

10.1 Incidental Findings in Genetic Testing

Genetic testing, particularly when applied to several family members, often leads to unintended results that were not part of the original scope of the investigation. These incidental findings can include unexpected information such as non-paternity or the discovery of genetic mutations that may have significant health implications for the tested individuals. It is difficult to predict the likelihood and significance of such findings beforehand, yet ethicists argue that patients should be informed about the potential for incidental discoveries before undergoing genetic testing. (Fisher et al.,2016) suggest that anticipating such results is essential for managing patient expectations.

The disclosure of incidental findings has been a subject of considerable debate. The American College of Medical Genetics and Genomics (ACMG) issued recommendations on returning incidental findings from whole-genome sequencing, emphasizing beneficence over autonomy in making decisions about whether or not to disclose these findings (Damschroder et al.,2009). Although many ethicists argue that autonomy—respecting a patient's right to make decisions about their own body—is the most critical principle, the ACMG prioritizes beneficence, which aims to act in the best interest of the patient (Kirk et al.,2016). (Mallal et al.,2008), returning incidental findings is important and should align with evidence-based practices and patient preferences. As genetic research continues to evolve, it is imperative that guidelines for handling incidental findings are developed to ensure clarity and consistency in practice (Gallego et al.,2015).

10.2 Service Availability in Personalized Medicine

The Universal Declaration on Human Genome and Human Rights (1997) asserts that the benefits of advancements in biology, genetics, and medicine should be accessible to all, not just to those who can afford them. However, many of the services associated with personalized medicine, such as gene editing, are prohibitively expensive and often not covered by insurance, leading to significant disparities in access to these treatments. For example, gene editing for cancer, although potentially life-saving, is a costly treatment that is often inaccessible to the general population due to high costs and limited insurance coverage. On the other hand, FDA-approved medications like Herceptin, which treat HER2-positive breast cancer, although expensive, are covered by insurance in countries like Iran. (Basu et al.,2016) argue that insurance and regulation are essential to ensure the equitable distribution of these resources, particularly to marginalized groups, such as the poor and the illiterate.

The high cost of personalized medicine, including advanced laboratory testing and specialized medications, limits access to these treatments. As a result, only those who can afford these services benefit from their availability, further deepening health inequities. The principle of justice demands that all individuals, regardless of their socioeconomic status, have access to the benefits of personalized medicine. This requires addressing the systemic issues that restrict access to these treatments and ensuring that policies are in place to promote fairness and equity in the distribution of healthcare resources.

10. 3 Justice and Equity in Personalized Medicine

The issue of justice in personalized medicine also extends to the fairness of research practices and the inclusion of diverse populations in genetic studies. Historically, research studies have predominantly involved participants from Western, industrialized countries, often overlooking individuals from minority and low-income groups. According to (Relling et al.,2011), less than 10% of participants in genetic research studies at the National Human Genome Research Institute (NHGRI) were from Asian countries, highlighting the underrepresentation of these populations in genomic research. Such discrepancies in research participation lead to uneven representation in the findings, which can affect the efficacy and applicability of treatments in diverse populations.

The unequal distribution of health resources, especially in underserved communities, is exacerbated by the rise of personalized medicine. (Relling et al.,2013) note that access to a healthy diet and lifestyle, as well as medical resources, is often limited in disadvantaged communities, leading to health disparities. These disparities may worsen as personalized treatments, which are designed to address individual genetic differences, are made available only to those who can afford them. To achieve justice in personalized medicine, it is crucial to ensure that research methods are inclusive and that treatments are accessible to all racial and ethnic groups (Kimmel et al.,2013).

Moreover, governments, businesses, and insurance companies have a responsibility to ensure that the costs of developing new personalized medicines do not disproportionately affect minority groups. (Pirmohamed et al.,2013) argue that there are ethical concerns related to the rising costs of drug development and how these costs may be passed on to minority populations, further exacerbating existing inequalities. (Duconge et al.,2015) suggests that legislators should play a critical role in safeguarding the equitable distribution of personalized medicine, ensuring that policies are in place to prevent discrimination and promote fairness.

10.4 The Physician-Patient Relationship in Personalized Medicine

The implementation of personalized medicine also raises important concerns about the physician-patient relationship. (Chambers et al.,2016) identify several challenges, including time constraints, increased patient involvement in healthcare decisions, and inadequate training of healthcare professionals. These factors can negatively impact the doctor-patient relationship, especially when genetic testing becomes more prevalent in medical practice. Personalized medicine requires a patient-centered approach, which calls for healthcare professionals to spend more time with patients

Table 1. Positive and negative effects and ethical considerations of personalized medicine

Negative effects	**Positive effects**	**Ethical considerations**
High cost		Increase personal responsibility
Inequality in health care	Improving quality of healthcare (accessibility, effectiveness, affordability, public trust)	
Violation of privacy		Individual vs. societal rights in access to information
Discrimination		
Negative effect on physician-patient relationship		
Stigmatization	Fair subject Selection	Informed consent Incidental findings
Exploitation		Genetic counseling

Table 2. Connections between Relational Ethics concepts and Bioethics concepts

Relational Ethics Concepts	**Relevant Bioethics Concepts**
Mutual respect	•Respect for persons •Beneficence •Non-maleficence •Privacy •Confidentiality •Autonomy
Engagement (Establishing a patient–provider relationship)	Beneficence •Privacy •Confidentiality •Informed consent •Fiduciary responsibility
Embodied Knowledge (Patient's lived experiences)	•Non-maleficence •Autonomy •Informed consen
Environment (Patient's needs, preferences, values, family, community, History)	•Non-maleficence •Justice
Uncertainty (Decisions based on different value-based demands)	•Autonomy •Burden of knowledge

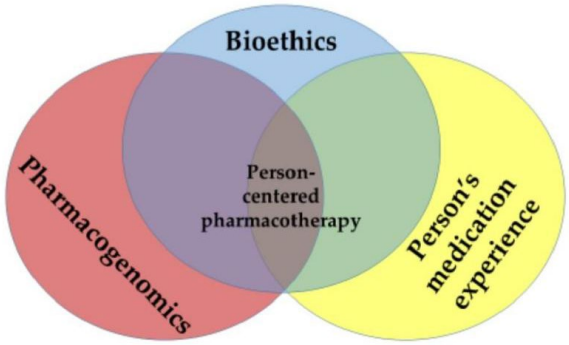

Figure 1. Person-Centered Personalized Pharmacotherapy: The Intersection of Pharmacogenomics, a Person's Medication Experience and Bioethics.

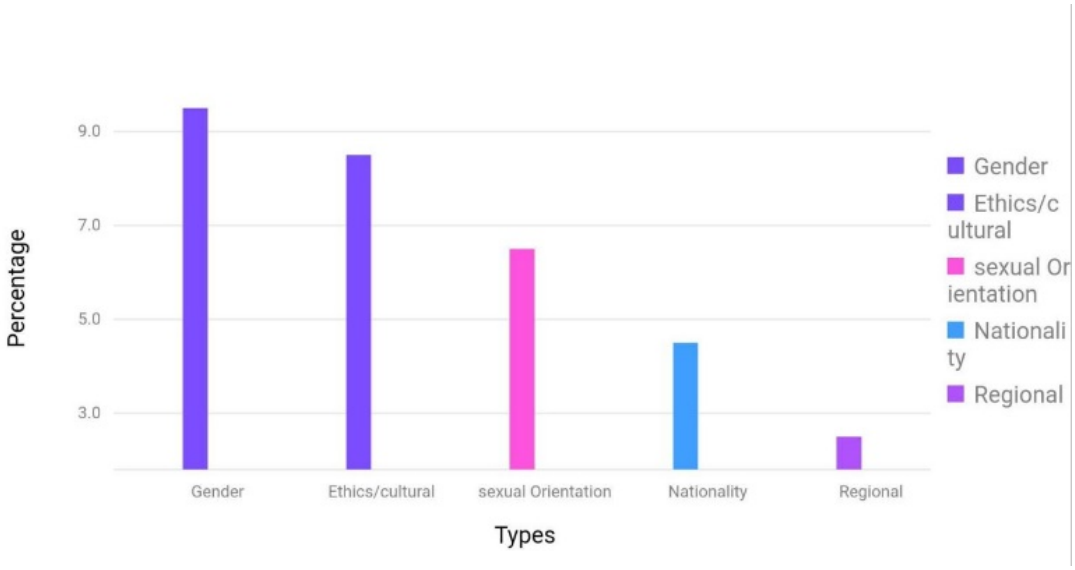

Table 2. Endorsement Different Types of Discrimination

and ensure that they understand the implications of genetic testing and the results.

The physician-patient relationship in personalized medicine can be strained if patients are reduced to their genetic characteristics, rather than being treated as holistic individuals. (Aronson et al.,2015) emphasize that respecting a patient's dignity and treating them as a whole person, rather than focusing solely on their genetic traits, is essential to maintaining a strong doctor-patient relationship. Genetic counseling is necessary before genetic testing to ensure that patients understand the purpose of the test and the potential societal implications of the results. Without proper counseling, patients may not fully comprehend the ramifications of the testing, leading to misunderstandings and potential harm to the physician-patient relationship (Curran et al.,2012).

In addition, genetic testing in personalized medicine may lead to uncertainties regarding the interpretation of results. Healthcare providers must navigate these uncertainties carefully, providing patients with clear guidance and support throughout the process (Fiscella et al.,2015). Personalized medicine should enhance, rather than hinder, the quality of care and the relationship between physicians and patients.

The ethical and practical challenges of personalized medicine—incidental findings, service availability, justice, and the physician-patient relationship—require careful consideration and thoughtful policy development. Ensuring that the benefits of personalized medicine are accessible to all, that incidental findings are appropriately disclosed, and that healthcare professionals maintain strong relationships with their patients are essential steps in the responsible implementation of these innovative treatments. By addressing these issues, we can ensure that personalized medicine fulfills its promise of improving healthcare outcomes while upholding the principles of justice, autonomy, and beneficence.

11. Discussion

Customized medicine represents a dual focus on individual care and global health, and ethical considerations must be integrated when tailoring treatments for both individuals and society at large. The assessment of personalized medicine should take into account both personal and societal factors in the research, development, and delivery of medical services. As (Grady et al.,2013) noted, it typically takes about 17 years for new findings to be incorporated into standard medical practice. This delay underscores the challenges faced in implementing customized medicine, particularly due to our still-limited understanding of pharmacogenetics, which calls for extensive genomic studies. Consequently, personalized medicine cannot be fully justified in its current form without addressing these challenges, especially from an ethical standpoint.

Despite these obstacles, personalized medicine is steadily gaining traction in clinical settings, and genetic testing is becoming an integral part of healthcare services. It is evident that genomic data will play a significant role in the future of medicine. This progress highlights an urgent need for more sensitive and accurate genetic testing tools, which should be widely accessible to ensure that personalized medicine can be implemented more effectively. Furthermore, precise tools for monitoring off-label drug uses and conducting post-approval surveillance are essential for evaluating the safety and efficacy of treatments over time.

For personalized medicine to have a positive impact on healthcare quality, strategic planning and policy development must be put in place. These changes should encompass both ethical and economic considerations, ensuring that the transition to personalized medicine is holistic and inclusive. As part of this process, several key ethical challenges must be addressed. The most pressing ethical issues in pharmacogenetics—the scientific basis for personalized medicine—include confidentiality regarding the storage of genetic data, equity in drug development and access to genetic testing, and the right of individuals to choose whether to undergo genetic testing (Kelley et al.,2015).

Moreover, some genetic findings may take time to attain therapeutic relevance, underscoring the importance of informed consent, clear communication regarding objectives and patient expectations, and transparent discussions between patients and healthcare providers. By fostering a scientific partnership, these issues can be resolved, improving the overall ethical framework of personalized medicine.

Ultimately, decisions regarding personalized treatments should be made on an individual basis, guided by ethical principles. To support this, it is critical to develop a comprehensive framework that addresses the moral and societal challenges posed by personalized medicine. This framework should account for values that influence decision-making and study design, helping to resolve ethical dilemmas in research and clinical practice. Such a framework would be integral to the successful implementation of personalized medicine in both research and healthcare delivery (Prasad et al.,2014).

12. Conclusion

In conclusion, the ethical issues associated with the application of precision medicine emphasize the need for a responsible and balanced approach to fully realize the potential of this innovative healthcare sector. As we delve into the complexities of data ownership, informed consent, privacy protection, equitable access, and the possibility of unintended consequences, it becomes evident that ethical frameworks are not only morally imperative but also crucial for advancing healthcare. These frameworks ensure that precision medicine is implemented in a way that benefits individuals and society as a whole.

Building trust among those contributing to genomic databases is essential to safeguard the sensitivity of genetic information and protect patient confidentiality. It is also crucial to avoid exacerbating existing health disparities by ensuring fair access to precision medicine. Achieving this balance requires a commitment to accessibility and affordability while preventing the emergence of a healthcare system that disproportionately favors the wealthy.

Clear communication is identified as the cornerstone of informed consent, empowering individuals with a thorough understanding of the complexities involved in personalized treatments and genomic testing. Ethical obligations also extend to clarifying data ownership, creating rules that uphold individual rights, and prohibiting the commercial exploitation of genetic data. Moreover, it is essential to anticipate and address the potential long-term consequences of genetic data, as it is permanent and can affect future generations.

Establishing trust among the public, researchers, and healthcare professionals is vital as these stakeholders engage in ongoing discourse. Open communication not only addresses concerns but also reinforces the moral commitment required for the responsible development of precision medicine. As we move forward into this transformative phase of healthcare, it is crucial that ethical principles are integrated into the core of precision medicine. By establishing clear norms, regulatory frameworks, and a strong commitment to ethical behavior, we can ensure that the benefits of this cutting-edge approach are realized in an ethical and equitable manner, ultimately improving global health outcomes.

Author contributions

A.Y. contributed to data analysis, visualization, and interpretation. J.A.C. was responsible for supervision, critical revision of the manuscript, and project administration. Both authors read and approved the final manuscript.

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Competing financial interests

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