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Current Perspective Of Pharmacogenomics In Clinical Practice In India

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Abstract:

Pharmacogenomics is a new field of study that investigates how genetic characteristics influence a person's drug response. Pharmacogenetics investigates "monogenetic variants" that affect the pharmaceutical response, whereas pharmacogenomics investigates the "whole spectrum of genes (genome)" that can influence therapeutic efficacy and safety. Both names, however, are used interchangeably. PGx-guided drug therapy seeks to provide predictive, preventative, and customized medication in clinical practice by utilizing genetic data. To thoroughly assess a patient's response to a specific pharmacological therapy, PGx integrates knowledge of drug pharmacokinetics and pharmacodynamics with contemporary genetic testing. Researchers can discover the causal genetic state for a drug's modified pharmacokinetic and pharmacodynamics activity by integrating an individual's genetic profile with clinical and environmental factors. Technological improvements in human genetics have supported and spurred tremendous progress in PGx research, ranging from single-nucleotide polymorphism (monogenic) evaluation to a comprehensive genome-wide approach (oligogenic). Pharmacogenomics is proving to be quite beneficial to the health care system. However, before completely adopting this branch, higher authorities must frame and address several social, legal, and ethical issues, as well as give incentives to overcome technical hurdles. To integrate pharmacogenomics into clinical practice through MTM, the pharmacy profession must define a process for applying pharmacogenomic data into pharmacy clinical practice that is aligned with MTM service delivery, develop a viable business model for these practices that encourages and promotes the use of pharmacists' clinical expertise, and encourage and direct the development of technology solutions that support the pharmacist's role.

Keywords: Pharmacogenomics, Clinical Pharmacist, India, Personalized medicine

Introduction:

Despite individual genetic differences in drug response, current drug therapy concepts usually try to treat large patient populations as groups, utilizing a "one size fits all" approach to drug prescription and administration. About 25%–60% of individuals respond favorably to their medications. The balance of the patients, however, face significant treatment delays due to pharmacogenomic variations. It raises the likelihood of adverse drug reactions (ADRs), which lengthen hospital stays and are the world's sixth-leading cause of death [1].

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Pharmacogenomics is a new branch of study that looks into genetic influences on a person's drug response. Pharmacogenetics studies "monogenetic variations" that affect the drug response, whereas pharmacogenomics studies the "entire spectrum of genes (genome)" that can influence therapeutic efficacy and safety. However, both terms are used interchangeably. [2] It combines expertise in medication pharmacokinetics and pharmacodynamics with cutting-edge genetic testing to analyze a patient's response to specific pharmacological therapy[3]. When medication is provided using the "one dose fits all" concept, a considerable number of people develop resistance, some respond differently, and others develop severe adverse effects in a given homogeneous population. With the completion of the Human Genome Project and the subsequent development of complete high throughput "omics" technologies, a genomic medical revolution has begun in recent years. Surprisingly, despite these advances in medical therapy, drug efficacy variability and drug toxicity remain major concerns in healthcare systems. Genetics is important in understanding illness causation, but it also contributes significantly to medication disparities[4]. Treatment outcome variability is mostly produced by inherited (germline) or acquired (somatic) changes in the gene sequence that codes for the proteins involved in medication absorption, distribution, metabolism, and excretion (ADME). These genetic differences are currently being exploited in clinical medicine to predict dose needs, therapeutic response, and drug-induced toxicity under the disciplines of pharmacogenetics and pharmacogenomics (PGx). [5]

Evolution of Pharmacogenomics in India :

Vogel developed the term Pharmacogenetics in the 1950s, following the discovery of several enzyme polymorphisms (e.g., N-acetyltransferase, G6PD). Due to its obscurity, the science of Pharmacogenetics eventually fell out of favor. In the 1970s, the discovery of the CYP2D6 polymorphism and its effect on drug toxicity and responsiveness resulted in a plethora of pharmacogenetic-based pharmacokinetic variations. Because of these and other discoveries, as well as the following ability to genotype, the term pharmacogenomics was coined. Today, a growing number of genes have been discovered with polymorphisms connected to differential drug response, whether at the level of the drug-metabolizing enzyme, transporter, or receptor, primarily employing a candidate gene(s) technique. OPTIMA (Omics for Precise Therapeutic Interventions Minimizing Adverse Drug Reactions) is an evidence-based approach to pharmacogenomics implementation with the goals of accelerating the incorporation of genomic evidence for optimal therapeutic or management strategy selection, enabling the mining and exploration of genome-scale datasets through close integration with clinical decision support engines or systems, and enabling collaborative research with clinics. Allow for the identification of at-risk people so that community interventions can be implemented. Provide free pharmacogenomics tests for succinylcholine and 5FU(5 Fluorouracil) if the patient has a prescription. [31]

Another example is the Council for Scientific and Industrial Research-IGIB, a constituent laboratory of the Council for Scientific and Industrial Research and one of India's major institutes for pioneering cutting-edge discoveries in genomic science (CSIR). The CSIR-IGIB conducts research in the following areas: Genomics & Molecular Medicine, Chemical & Systems Biology, Genome Informatics & Structural Biology, Respiratory Disease Biology, and Energy & Environmental Biotechnology. The CSIR IGIB has been a pioneer in translational genomics in India. The Genomics for Understanding Rare Diseases India Alliance Network (GUaRDIAN) concentrated its attention on translational research in 2015. The initiative has grown to be one of the largest of its type in the domain of Rare Genetic Diseases, with a clinical collaboration network of over 100 physicians from over 35 clinical centers across India working

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on Rare Diseases. Last year, the CSIR IGIB announced a new supplementary initiative called Genomics and other Omics Tools for Enabling Medical Decisions (GOMED), with the goal of making genetic tests more affordable and equitable. The program contains over 80 genes and has already served over 2000 patients from 25 different locations across India. As part of the collaboration, AIIMS Delhi and CSIR IGIB will collaborate in clinical settings on genetic disorders and genomics. This would require creating and taking part in cooperative, collaborative genomics studies to diagnose, determine prognosis, and precisely treat hereditary disorders. Faculty members from both institutes will be able to actively participate in developing and implementing collaborative initiatives aimed at accelerating the application of genomics in clinical decision-making[32].

The following are the list of companies offering pharmacogenomics tests in India

S.no	Company name
1	Mapmygenome India LTD
2.	CSIR Institute of genomics and integrative biology
3	Sandor
4	Ganit labs foundations
5	Xcelris – We make DNA speak
7	Ayugen– Biosciences
8	GeneOmbio
9	Med-genome
10	ArrayGen Technologies
11	Genes2me
12	Xcode life

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India's Pharmacogenomics :

The purpose of PGx-guided drug therapy is to give predictive, preventive, and personalized medication through the use of genetic data in clinical practice. By combining an individual's genetic profile with clinical and environmental characteristics, this aids researchers in discovering the causal genetic state for a drug's modified pharmacokinetic and pharmacodynamic activity. Human genetics technological improvements have supported and ignited remarkable progress in PGx research, from single-nucleotide polymorphism (SNP) (monogenic) assessment to a complete genome-wide approach (oligogenic). Both healthcare practitioners and pharmaceutical companies have increased their scope. They broaden the scope of clinical PGx beyond drug research, development, and clinical trials by implementing novel molecular-based methods and testing strategies. Intriguingly, in 460–370BC, the Greek physician Hippocrates emphasized the concept and importance of inter-individual variability when he observed, "It is more necessary to know what kind of person has an illness than to know what kind of ailment a person has." "Variability is the law of life," Canadian physician Sir William Osler observed in the 1800s, "and as no two faces are alike, no two bodies are equal, and no two individuals react alike and behave alike under the aberrant conditions we call sickness." Snyder's research into racial differences in taste blindness for phenylthiocarbamide throughout the 1930s heralded the beginning of PGx. [5]

Nonetheless, in 1959, the German physician Friedrich Vogel coined and published the term "pharmacogenetics." PGx has evolved into a major driving force as a result of a series of discoveries that has expedited its development. As with most pharmaceuticals, research focuses on uncovering genetic indications that can predict a drug's safety and effectiveness. THE US FOOD AND DRUG ADMINISTRATION (FDA) NOW REQUIRES PGx-RELATED INFORMATION AND WARNINGS ON DRUG LABELS DUE TO GROWING GENETIC UNDERSTANDING [5]. The purpose of this research is to provide up-to-date information on the state of pharmacogenomics research in the Indian population. Among the pharmaceuticals investigated in our laboratory are anticancer therapies, antiestrogen agents, antiplatelets, anticoagulants, HMG-COA reductase inhibitors, oral hypoglycemic medications, anticonvulsants, and analgesics. We also look at current concerns and studies from various therapeutic organizations in India. Precision medicine is the selection and administration of drugs based on genetic, environmental, lifestyle, and other unique patient or ailment characteristics. Precision medicine or customized medicine[6] are other terms for it. Pharmacogenetics/pharmacogenomics (PGX) is a discipline in precision medicine and personalized healthcare. PGX uses genetic information to predict a subject's response to a medication (responders versus no responders), as well as persons who are likely to experience side effects and the appropriate drug dosage. Significant advances in PGX and its importance in improving health care quality did not emerge until the human genome project was completed. Over the last two decades, PGX has grown increasingly essential in drug research and clinical treatment decisions. Before moving on to full-fledged effectiveness and safety investigations, medication manufacturers and other pharmaceutical research centers have begun to investigate novel compounds to see if they are metabolized by highly polymorphic routes. Additionally, drug regulatory bodies have developed recommendations and guidelines to promote and govern the use of PGX in clinical trials. The Food and Drug Administration (FDA) of the United States has authorized several drug labels that incorporate PGX-related information and recommendations. However, incorporating and implementing PGX in clinical practice is not without challenges[7]. The knowledge and experience of healthcare practitioners, for example, have been shown to lag in the adoption of PGX. In recent years, accrediting, educational agencies, and professional pharmacy associations have pushed for PGX instruction to be

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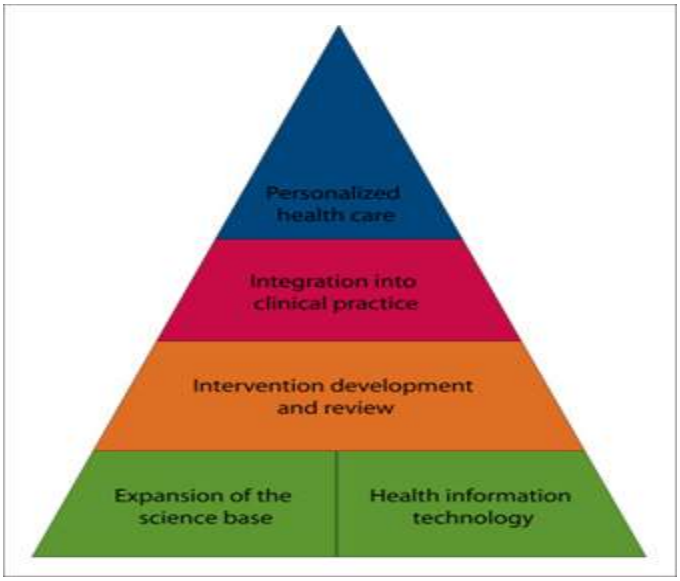
included in college curricula. [26] Another important consideration is the debates, knowledge gaps, and techniques around PGx testing in Indian personalized medicine. The limited availability of fast genetic testing, as well as the incapacity of healthcare practitioners to use these tests, continues to be a barrier to the development and deployment of PGX in clinical practice. Other barriers include a perceived lack of enough evidence for the PGX test's therapeutic value, a lack of access to the test, data security and privacy, cultural and religious views, and a lack of funds[27]. Essential resources include financial resources, infrastructure, qualified staff to provide the PGX service and a competent platform to store and interpret genetic data. The pharmacist's involvement in patient care has expanded to include pharmacokinetics, anticoagulation, antimicrobial stewardship, and pharmaceutical treatment management, among other specializations (MTM)[26]. The knowledge and abilities of clinical pharmacists in drug pharmacokinetics and pharmacodynamics provide them an advantage in taking the lead and delivering clinical services in the rapidly developing field of PGX[27]. In a draught statement on the pharmacist's role in clinical PGX, the American Society of Health-System Pharmacists (ASHP) emphasized the clinical pharmacist's capacity to lead inter-professional efforts to establish guidelines and protocols and launch PGX services[28]. Several institutions have already begun clinical PGX programs overseen by pharmacists. As a result, the pharmacist's potential involvement in the incorporation of PGX into pharmacy practice is becoming increasingly important. The purpose of this study is to present an overview of PGX in clinical pharmacy practice today, as well as current perspectives[30]. The research also looks at how to improve PGX teaching, implementation, and research in pharmacy practice in the future[28].

Initiative on Personalized Health Care:

In 2006, the Secretary of the Department of Health and Human Services (HHS) saw an opportunity to promote a new type of medical care: individualized health care (PHC). "The confluence of fundamental scientific breakthroughs in the human genome with computer-age ability to exchange and organize data," he characterized PHC as.

Figure 1. Personalized health care building blocks



The Secretary of Health and Human Services (HHS) saw an opportunity in 2006 to promote a new style of medical care: customized health care (PHC). He described PHC as "the convergence of fundamental scientific achievements in the human genome with computer-age ability to exchange and organize data."

Because of the knowledge gathered from the completion of the human genome, researchers can characterize variations in the biology of individual patients. Gene-based medicine is currently being used to treat individuals and will aid in the development of more effective treatments for large patient subpopulations. Patients benefit from the use of genetic information as PHC expands and becomes more widely used[25]. One of the first diagnostic tests was meant to detect how a patient's medicine was being metabolized. A simple test can tell whether a patient has a specific combination of genetic abnormalities in two liver enzymes that, on their own, metabolize about half of all drugs. Dosages can be adjusted depending on molecular metabolism rather than weight [26]. The regulatory component of the PHC Initiative stimulates the development of drugs, diagnostic tests, and medical commodities aimed at specific patient subpopulations. It is challenging for regulatory bodies to keep up with the rapid scientific and medical progress[27]. For example, the FDA's Critical Path Initiative has identified 76 scientific and regulatory areas where progress is needed to strengthen and expand the knowledge basis for medical product development. The FDA is also testing in vitro diagnostic approaches to identify sickness susceptibility [26]. Bioinformatics is another important discipline in implementing PHC. Computer models can assist predict drug effectiveness and safety by utilizing genetic factors. Because PHC demands the integration of several components, former HHS Secretary Leavitt anticipated that implementing the PHC paradigm would take a generation [22]. What began as a federal project will evolve into a collaborative effort including both the commercial sector and academia. Physicians, pharmacists, and other members of the healthcare team, patients, other health professionals, and other stakeholders will engage with the PHC framework's developers to ensure that it reaches its full potential[21].

Pharmacogenomics Status In India:

The benefits of pharmacogenomic testing over traditional clinical care include the capacity to stratify patients depending on projected pharmacologic requirements or results, which are classified into three categories: I estimating the ideal drug dosage; (ii) identifying patients who are at risk of drug-induced toxicity or unfavorable side effects; and (iii) determining the efficacy of an indicated medicine. Targeted medicines that improve treatment efficacy and minimize unexpected death and morbidity can also (iv) save healthcare systems significant money, even after accounting for the higher expenses of doing genetic tests. [10]

Since the dawn of time, pharmacology has been seeking to identify the right medicine in the right dose for the right person. For nearly a half-century, genetic influences on drug response have been established, giving rise to pharmacogenomics. It is well understood that systematic findings of genetic variation will lead to better diagnostic and therapeutic options. [12] The implementation of acceptable approaches for detecting genetic variance, as well as their future in the pharmaceutical sector for offering managed care as a financial incentive, will be a breakthrough. The primary goal of pharmacogenomics is to improve patient care. It is concerned with the genetic impacts of medications, as well as the genetic variation that leads to the diverse effects of medications in different people[14]. The application of genome-based

techniques has raised the likelihood of finding genetic influences on pharmaceutical action. Variation in genes is already being studied to account for variation in pharmaceutical effect[18].

Diagnostic tests are being developed to analyze the efficacy and safety of drugs in various people in order to help clinicians choose the best treatment and dose for their patients while reducing adverse drug responses. Proposed Pharmacogenomic Applications in Medicine Benefits Identifying multiple disease-related genes and genotype-specific medicine: more drug-specific treatment Human diseases will be able to be divided into subgroups. The development of new medical tests for specific diseases will aid in the detection of disease propensity as well as primary and secondary preventative measures for the benefit of the receiver. As a result, pharmacogenomics will provide a tailored strategy to patient management that provides the greatest benefit with the fewest negative effects. [15]

Technical Challenges:

The most important issue is the practical demand for drug development techniques that do not add cost, time, or complexity to the process. The Human Genome Project may hold the key to resolving all of these issues. [9]

Pharmacogenomics – a tool to increase efficacy:

Create a medicine regimen dosage that works for you. Traditional clinical medicine is based on the physician's clinical judgment and routine patient monitoring. Most drugs are available in commercially produced dose forms. These frequently contain the amount of active pharmacological components needed and appropriate for the majority of patients, or they can be easily changed based on patient-specific biometric characteristics like weight and age[22]. In contrast, a small number of pharmacological drugs require precise dose titration to produce the intended clinical impact within a local therapeutic index. Before finding the pharmacogenomic link between genetic profile and optimal drug dosage, this method of continual adjustment was partly a trial-and-error technique supplemented by rigorous and repetitive monitoring of patient response[20]. Warfarin, Irinotecan, and Atomoxetine are examples of medications for which dosage estimation based on clinical criteria such as age and weight performed poorly due to the presence of particular genetic differences that significantly correspond with different dose-response curves[18]. We want to make clear that genetic test results do not replace the need for clinical monitoring of a patient's reaction. Instead, knowing a patient's genetic profile guides the initial dose, hastening the process of discovering the appropriate medication dosage with the fewest side effects. [20]

Toxicity and adverse side effects are kept to a minimum:

Medication-related adverse events were one of the main causes of death in India, and a similar trend is gaining pace globally. In recent investigations, numerous genetic linkages with drug-induced toxicity and side effects have been revealed, and knowing an individual's genetic profile helps forecast the chance of an unfavorable outcome and guides the physician to different treatments if necessary and accessible. Patients who lack the HLA-B*57:01 and HLA-B*15:02 alleles for Abacavir and carbamazepine, respectively, are less likely to develop Abacavir-induced hypersensitivity or carbamazepine-induced Stevens-Johnson syndrome. Patients who possess these genes, on the other hand, are at a higher risk of unpredictable and potentially fatal reactions. As a matter of good clinical practice, doctors almost always

provide options. By switching non-abacavir-containing medicines for HLA-B*57:01 carriers, HLA-B*57:01 screening before Abacavir prescription has shown promising benefits in minimizing abacavir hypersensitivity in HIV patients. [18]

Finding effective medications is a difficult task:

Individual patient genetic profiles can be used to predict which patients will respond to medicine-laying the groundwork for more individualized treatment of diseases such as cancer, metabolic disorders, and infectious diseases. Vanderbilt University's Pharmacogenomic Resource for Enhanced Decisions in Care and Treatment (PREDICT) program has already shown how genetic test results have improved patient safety by simplifying the prescription of the appropriate drug and dosage of compatible statins to heart patients who were previously coping with ineffective treatments. Trastuzumab, also known as Herceptin, is an effective treatment for HER2-positive breast and gastric cancer patients, increasing survival and lowering the risk of cancer relapse by more than 10% over three years. HER2-negative patients, on the other hand, do not benefit from the same treatment. The ability to precisely pinpoint an effective treatment, particularly for a debilitating and psychologically traumatic condition like cancer, significantly boosts patient confidence in both the treatment regimen and genetic tests, as patients would otherwise face the double whammy of a rapid decline in quality of life and the high cost of potentially harmful treatment with questionable efficacy. [15]

Reduce the healthcare system's overall expenditures:

The potential for cost savings for the healthcare system is one aspect of pharmacogenomic testing that is commonly overlooked. Due to the added cost of genetic tests, the greater upfront costs frequently hide this benefit for individuals. Although Abacavir and simvastatin are much less expensive than their equivalents (Tenofovir and Alirocumab), they may cause unpleasant side effects. Allotting more expensive options to all patients incurs extra costs for the healthcare system and increases the likelihood of unpleasant effects. Unguided use of the less cost choices, on the other hand, can result in higher morbidity and a corresponding loss of quality of life due to side effects. Knowing the genetic profiles of the patients enables the assignment of more expensive medications to only those who are unable to tolerate the less expensive medications, resulting in significant cost savings for the healthcare system, even after accounting for the cost of pre-treatment genetic screening. This was the case for HLA-B*15:02 screening prior to carbamazepine prescription in East Asians, resulting in total savings for the healthcare system despite the requirement to test a larger number of patients to benefit one patient. Should be aware that cost-cutting discoveries are context-specific and not directly transferrable across other health systems, as illustrated by the discovery that HLA-B*57:01 testing is not cost-effective for Indians despite being proven to be so in other countries populations. Local variations in allele prevalence and healthcare cost structure can result in contradicting economic modeling results. [11]

The healthcare system's ramifications:

The use of pharmacogenomic data in clinical practice is predicted to increase patient safety while decreasing costs. It is predicted that 1.5 million serious medication errors are avoided in India each year. These results translate to a total of 177 billion in healthcare and death-related expenses. Furthermore, targeted medications make about 40% of all compounds under development. [8] The majority of these

drugs will be used to treat cancer and will take into account a patient's genetic or biomarker data. Clinical trials, personal testing, and the creation of new medications all have the potential to reveal genetic information. The data must be methodically gathered, compiled, saved, shared, and safeguarded. This type of system will produce an effective and efficient tool for researchers, industry, and the healthcare community to use in the therapy decision-making process. It will have far-reaching consequences for the healthcare system. While information technology professionals work on electronic patient management systems, regulatory, clinical, and scientific staff collaborate to build a knowledge base of pharmaceutical therapy and pharmacogenomics that can help influence decisions[8]. Pharmacogenomics has the potential to significantly improve patient care in the healthcare system. Addressing current barriers, concerns, and system limitations, as well as developing a future infrastructure in which all health care providers can collaborate to improve patient care by using pharmacogenomic data in clinical practice, will undoubtedly improve patient care, achieve better outcomes, and improve health care. [11]

Students' knowledge and perspectives on pharmacogenomic teaching in medical school:

It is vital to educate students about the importance of PGx education in medical schools. In response to the increased need, various international organizations have undertaken efforts to include traditional pharmacogenomic training in medical, pharmacy, and public health schools. [13] In 2005, the International Society of PGx (ISP) published recommendations for PGx undergraduate medical education. With this context in mind, we undertook this study to examine second-year MBBS students' knowledge and perspectives on the importance and relevance of PGx in the medical curriculum, as well as to sensitize and elicit their opinions on how to apply this growing science in practice to maximize therapy. With a few exceptions, the majority of the pupils had a solid comprehension of PGx and its significance. [14]. The majority of students were not aware that pharmacogenomic changes in drug targets, metabolizing enzymes, and transporters had an impact on medication therapy. Similarly, many students were unable to grasp how pharmacogenomic data could help reduce pharmaceutical development costs and increase the availability of pharmacogenomic tests in India. An Internet search revealed that no study in India documented healthcare students' perspectives on PGx and its inclusion into medical education. The textbook is the primary source of PGx information, followed by the Internet. [11][8].

With a few exceptions, the majority of the pupils had a solid comprehension of PGx and its significance [10].

Despite the fact that the terms PGx and personalized medicine were discussed in general pharmacology classes, only 54% of students correctly defined them. They emphasize the significance of this rapidly expanding issue; in 2005, the ISP education conference advocated a minimum of 4 hours of undergraduate PGx teaching to medical students by incorporating it into the fundamental pharmacology curriculum in the education of physicians, pharmacists, and nurses. This can be accomplished by case-based learning, routinely recognizing typical examples of polymorphisms affecting pharmacodynamics and pharmacokinetics, and delivering continuing medical education (CME) in hospitals[4]. They also requested pharmacology textbook publishers to add a chapter on PGx, as well as the pharmaceutical industry to provide web-based learning resources. Students displayed a strong comprehension of and interest in PGx in general, but their knowledge of applying and interpreting PGx was limited. As technology and understanding of the human genome advance, the availability of simple-to-use, cost-effective, and reliable-to-interpret tools/biomarkers will result in treatment with maximum efficacy, little

toxicity, and affordable healthcare costs. As a result, we advocate for (1) primary pharmacogenomic education at all levels of medical curricula, (2) the development of case-based knowledge application modules, (3) regular CME to stay current on available screening tools/biomarkers, and (4) patient and public awareness programs to ensure that clinicians and patients are on the path to precision medicine. [5]

Clinical Pharmacists are Impetus for Implementation of PGx into the practice

As the twenty-first century approaches its second decade, PGx (the use of genetic data to anticipate an individual's reaction to a medicine) will play an increasingly essential role in drug research and clinical treatment decisions. Using genetic information from patients to personalize pharmacological therapy reduces the risk of side effects, improves patient outcomes through targeted medicines and dosing, and streamlines the drug development process. By shifting away from a one-size-fits-all approach to pharmacological therapy and toward a patient subpopulation or patient-specific strategy, the pharmaceutical and clinical communities are one step closer to implementing the new medical paradigm of customized health care. By introducing PGx into clinical practice, pharmacists can assist in improving the quality and safety of health care. As pharmacogenomic applications progress, the pharmacy profession has begun to define its role and address processes for efficiently integrating pharmacogenomic applications into clinical practice. Medication therapy management in clinical pharmacy is one technique to put the PHC Initiative into action (MTM). This service assists patients in achieving the best possible treatment outcomes. Pharmacists, as important health care providers in MTM service delivery, assess and evaluate a patient's whole pharmaceutical therapy regimen through a comprehensive or focused medication therapy review, rather than focusing on a single therapeutic product. [12]

By obtaining crucial information, pharmacists can identify potential interactions, offer an alternative therapy to prevent medication-related bad effects, and effectively communicate with the individual patient's other health care providers to optimize overall care and treatment outcomes (e.g., all medications a patient is taking, including supplements). Pharmacists are increasingly providing MTM services to patients in a variety of patient care settings to assist them to achieve improved treatment outcomes. pharmacist-provided MTM provides unique new and expanding opportunities to incorporate PGx into clinical practice as well as actively collect, interpret, and use pharmacogenomic data to improve patient care. According to former HHS, "pharmacists have long been on the front lines in counseling consumers about the proper use of their medicinal products." As PGx and increasingly personalized treatment become more popular, pharmacists will continue to play an important role in improving the quality and safety of patient care. Because most genetic counselors are unable to adequately investigate the genetic contributions to the overall pharmacological management of medical diseases, a new model for counseling on pharmacogenomic data at the patient-physician level is required[11]. Can include PGx into MTM service delivery to allow pharmacists to contribute their knowledge to the treatment planning process, leading to improved treatment outcomes. Because of their in-depth medication training, pharmacists may analyze all of the prescriptions prescribed for a patient, as well as the patient's genomic data, and offer an opinion on whether a prospective drug would be the greatest fit for the condition and patient. They could work with the prescriber and the lab to do this. As part of a collaborative health care team, pharmacists can optimize drug selection and dosing and, if necessary, offer alternatives to improve therapy outcomes. However, there are numerous benefits to utilizing pharmacogenomic data and determining how to communicate such information to health care practitioners. E-prescribing systems, which are now available, are one form of distribution. [15] E-prescribing platforms, on the other hand, are

progressively being integrated into EHR capabilities. Integration and transfer of PGx information as a component within the EHR may give a more practical option for exchanging this data. To develop a PGx component within an EHR, individuals who generate PGx data and those who will use the data must first identify key PGx components that will be most relevant in clinical treatment decisions. [14] Despite the task's complexity, work has been made in a number of areas to bring PGx's promise to patients. Moving forward, pharmacists must define a process for integrating PGx data into pharmacy clinical practice aligned with MTM service delivery, develop a viable business model for these practices that encourages and promotes the use of pharmacists' clinical expertise in collaboration with other health care providers and labs, and encourage the use of PGx data in pharmacy clinical practice aligned with MTM service delivery. [11]

Pharmacogenomics' Future and Challenges:

In clinical practice, the usage of PGx has been proven in the literature to improve the efficacy of several drugs while minimizing their negative effects. A recent paper provided an overview of the evolution of pharmacogenomics in clinical pharmacy practice, as well as its adoption, education, and research. [8] The authors believe that combining "omics" data (epigenomics, transcriptomics, proteomics, and metabolomics) will be critical for future PGx and precision medication implementation models. These improvements will surely need health information technology (health informatics) solutions and effective EHR systems[26]. Because of the revolution in whole-genome sequencing and the enormous fall in its cost, genetic data should be available at the tip of our fingers. The most major challenges continue to be data storage, quality assurance, mapping, and EHR integration. Furthermore, in order to avoid bias based on DNA, we must thoroughly evaluate ethical, legal, and social issues. [23] More outcome-based studies are required to assess the impact on health outcomes as the use of precision pharmacotherapy is widely acknowledged and implemented in a variety of practice contexts. Furthermore, advanced pharmacist responsibilities in PGxs in clinical practice in India may demand specialized education, training, and relevant experience [20]. More PGx material and courses are expected to be included in pharmacy school curricula and certification programs around the world. Because of the need for infrastructure, resources, and capacity building, the adoption and implementation of PGX in clinical practice in resource-constrained places may be slow. [24]

With more study and developments in PGx, it is possible that this information will be used in medical prescriptions in the future. SNP variant profiles may lead to more individualized medical prescriptions according to each individual's specific needs. This has the potential to boost medication efficacy while decreasing toxicity and side effects. However, in comparison to other developed countries, India's knowledge should be raised. Because PGx application is limited in India, pharmacists have a unique potential to enhance PGx research and implementation. More research is needed before pharmacogenetics may be used in primary care and prescribing. Despite our lofty goals, some practical issues must be addressed in the future, such as the vast number of variables that can affect a patient's response to a medication. More conclusive PGx research is hoped to be done in the future, paving the way for its incorporation into medical practice. The findings hold a great deal of promise for enhancing patient responsiveness to medication and overall healthcare. [25-33].

Conclusion:

Pharmacogenomics is proving to be a boon to the medical community. However, before fully implementing this branch, higher authorities should frame and handle several social, legal, ethical, and incentive issues in order to overcome technical challenges. To achieve pharmacogenomics integration into clinical practice through MTM, the pharmacy profession must define a process for applying pharmacogenomic data into pharmacy clinical practice that is aligned with MTM service delivery, develop a viable business model for these practices that encourages and promotes the use of pharmacist clinical expertise, and encourage and direct the development of technology solutions that support the pharmacist's role. To optimize the pharmacist's contributions to pharmacogenomic applications, continued development in these crucial areas is critical.

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