MINI REVIEW - OPEN ACCESS

Journal Of Pharmacy And Experimental Medicine

Contents lists available at bostonsciencepublishing.us

Journal Of Pharmacy And Experimental Medicine

The Status QUO of Pharmacogenomic Education in Pharma Curriculum

Keziah Ann Babu[1], Manjula Devi AS[2]

[1]Pharm. D Intern, College of Pharmacy- Sri Ramakrishna Institute of Paramedical Sciences, Coimbatore, E-mail: keziahannbabu@gmail.com; Phone: +918489698144
[2]M.Pharm, Ph.D, Associate Professor, Department of Pharmacy Practice, College of Pharmacy-Sri Ramakrishna Institute of Paramedical Sciences, Coimbatore, E-mail: hari1509@gmail.com; Phone: +919443776673

ARTICLE INFO

Article history:
Received 12 January 2021
Accepted 10 Febraury 2021
Revised 15 Febraury 2021
Available online 20 February 2021

Keywords:
Pharmacogenomics
Pharmacy curriculum
Pharmacy education
Precision medicine
Research
Strategies

ABSTRACT

This paper aims to bring out the significance of pharmacogenomics, the barriers seen in pharmacogenomic education and possible strategies to uplift pharmacogenomic education in pharma curriculum. Pharmacogenomics is an advanced field of drug therapy which is based on genetic data. It has wide potential in the future and is being increasingly studied. Personalized therapy based on genetic information of patients is the key concept of pharmacogenomics. Pharmacists have an important role to play in utilizing genomic data in optimizing patient's therapy. For this, effective training and education is required. The present pharma curriculum is sufficient to introduce the concept of pharmacogenomics to pharmacy students but is often found to be insufficient in developing practical and clinical decision-making skills in them. Hence, the future of pharmacogenomic education demands, developing and testing new educational strategies to enhance the skills of pharmacists in the coming years.

1. Introduction

The field of Pharmacogenetics incorporates data on human genetics into the science of pharmacology. Pharmacogenomics, on the other hand, involves a combination of gene expression profiling, proteomics, and bioinformatics. The former is used to describe the study of genes involved in drug metabolism, while the latter is a broader field that describes the study of the human genome that may help determine drug response in individuals (Pirmohamed, 2001).

Both these fields are more or less overlapping and are of great capability for utilization in the practice of precision medicine.(Gurwitz, *et al*., 2005). Pharmacogenomics (PGx) is a rapidly evolving area, used to identify the safe and most effective treatment for patients. With the completion of the Human Genome Project, research in PGx has evolved. Pharmacogenetic studies use data on genetic polymorphisms to identify effects of genetic variation on individual patient drug response and/or toxicity (Kisor, Smith, & Grace, n.d.). Certain observations were already made five to six decades ago, that diversity in responses of some drugs are attributable to genetic varaiation (Meyer, 2004). These clinical genomic information can be used in clinical laboratories, incorporated into electronic health records, and also can be utilized to alter drug therapy for specific individuals (Weinshilboum & Wang, 2017).

Pharmacogenomics, can allow for maximization of therapeutic benefits of drugs to patients as it provides a clearer picture of the patient's disease and thereby can help tailor use of medications in individuals. With advances such as these in pharmacotherapy, pharmacists are required to develop skills in recommending therapeutic regimen to physicians for specific patients (Marcinak, Paris, & Kinney, 2018). Implementation of pharmacogenomics into the practice of medicine allows provision of highly specific treatment for each individual patient thereby resulting in large scale reduction in the incidence of adverse events (Gurwitz, *et al*., 2005). The basis of inter individual variability in drug response depends on multiple factors, such as genomics, epigenomics, environment factors and patient specific characteristics, such as gender, age, concomitant drug therapy etc (Schwab & Schaeffeler, 2012).

Pharmacists also can take part in this by combining the data on patients' genetic makeup, with their knowledge of a drug's pharmacokinetics and pharmacodynamics to provide optimal therapeutic plan for individuals (Marcinak, *et al*., 2018). The use of pharmacogenetic testing can help predict individual drug dose, predict absence of response to a drug and identify individuals at serious risk of toxicity, if a drug is prescribed (Daly, 2017).

Certain individuals metabolize certain drugs much slower or much faster than normal due to genetic polymorphism in cytochrome P450 gene. For example, 'CYP2D6 poor or ultra-rapid metabolizers' metabolize many antipsychotic and antidepressant drugs at very slow or too rapid rates, respectively. 'CYP2D6 poor metabolizers' are at an elevated risk for ADR, while 'CYP2D6 ultra-rapid metabolizers' often do not

* Corresponding author.
Keziah Ann Babu, Pharm. D Intern, College of Pharmacy-Sri Ramakrishna Institute of Paramedical Sciences, Coimbatore, India. Phone: +918489698144
E-mail address: hari1509@gmail.com

receive the desired therapeutic outcome due to reduced drug efficacy. Therefore, it is essential to identify individuals who are susceptible in order to reduce the incredibly high current ADR rates, which have become a major cause of morbidity and mortality worldwide (Gurwitz, *et al*., 2005).

New findings in pharmacogenomics can help identify the interaction of drugs with receptor binding site, predict the absorption, distribution of drugs and elimination of the drugs from the body (T P, 2009).

If pharmacists are to become experts in personalized medicine, they must be well equipped to provide recommendations in genetic testing, interpreting and applying results for clinical and therapeutic decision making, and teaching pharmacogenomic concepts to other healthcare professionals (Mccullough, *et al*., 2011).

The role of pharmacists will depend on the training, education, expertise and the clinical setting. All pharmacists should have a basic understanding of pharmacogenomics, which will help them carry out some basic pharmacogenomic activities, while pharmacists specializing in pharmacogenomics can provide additional services (Awaisu, 2019).

2. Constraints of the Current Pharmacogenomic Education

In spite of the efforts made in incorporation of pharmacogenomics in pharmacy and medical schools, there appears to be a lack of vigor concerning its educational aspects as only very few institutions worldwide have implemented it in their pharmacology curricula. (Gurwitz, *et al*., 2005)Although pharmacy students are taught the basis of pharmacogenomics which includes introduction to pharmacogenomics and pharmacogenetics, adverse drug reactions attributed to genetic differences, genetic polymorphism in drug metabolism, drug transport, drug targets, pharmacokinetic and pharmacodynamic considerations attributable to genetics, they often find it as a theoretical science. Students require training in implementing pharmacogenomic principles to drug therapy, selection and monitoring. Nonetheless, efforts should be made in improving competency of pharma students and professionals by conducting continuing education programs.

To promote the inclusion of pharmacogenomics education in pharmacy curriculum, the Accreditation Council for Pharmacy Education (ACPE) provides standards, to include pharmacogenomics as a required element of the Doctor of Pharmacy curriculum. It emphasizes that this cannot be considered optional in the curriculum and should be taught at an appropriate level for students to apply their knowledge to patient care."

The objective of all this is to provide proficiency in understanding the mechanisms by which genetics can lead to disease, understanding how mutations can affect pharmacokinetic and pharmacodynamics, predicting treatment plans that may be influenced by an individual's genetic makeup with use of case-based strategies and the Pharmacogenomics Knowledge base (PharmGKB) and the Clinical Pharmacogenetics Implementation Consortium (CPIC) guidelines as resources, and weighing the benefits of using patient's genetic information with the potential social and ethical consequences (Marcinak, *et al*., 2018).

Factors affecting educational aspects included:

(1) lack of experienced teaching faculty

(2) challenges to keep up-to-date with current data

(3) the necessity to incorporate pharmacogenomics into pharmacy curriculum without compromising other important topics (Kisor, *et al*., n.d.).

Several strategies to improve the use of pharmacogenomics are being tried out. There remain barriers to its full implementation in clinical settings. Challenges include incorporating genomic data into the electronic health records, ethical concerns and clinical education. As drug experts, pharmacists can help overcome these barriers. Pharmacogenomics is being given increased importance in pharmacy education than past decades.

In spite of all these efforts, pharmacists and other health professionals often feel a lack of confidence in applying pharmacogenomics to cases. This specifies the need for training in this area. Pharmacogenomics is increasingly being incorporated in colleges of pharmacy, but this is often inconsistent with regards to its nature of teaching content and teaching strategies used and is limited in practical training (Weitzel, Aquilante, Johnson, Kisor, & Empey, 2016).

Continuing education programs in pharmacogenetics has been a main focus of many colleges of pharmacy as well as many national pharmacy organizations but only a few pharmacists receive such pharmacogenetics training. With a lack in formalized education in pharmacogenetics, it is not surprising that the majority of pharmacy graduates have very little knowledge on pharmacogenomics (Riper, n.d.). On the whole there is a need for developing and implementing new and effective strategies for pharmacogenomic education.

3. Manoeuvres to Improve Pharmacogenomic Education

DAt present doctors diagnose and prescribe drugs on an empirical basis and pharmacists look out for side effects, drug-drug interactions and other drug related problems. But in the days to come gene reports may be preferred to blood reports. In such a situation pharmacists could interpret the genetic results and take part in selecting optimal therapeutic regimen for patients based on their genetic makeup (T P, 2009).

Pharmacists are ideal persons capable of clinically applying the pharmacogenetic data to optimize drug efficacy, safety and therapeutic outcomes, and cost effectiveness. It is vital that future pharmacists have adequate experience with practical application (Kisor, *et al*., n.d.).

There remains significant educational needs and challenges in traditional, laboratory, and practical teaching areas in pharmacy education. It is seen that PGx is often incorporated as a part of a subject rather than a separate field. It would be ideal to use case studies in PGx education to improve understanding. (Weitzel, *et al*., 2016)The most frequently used educational tools for teaching PGx are original research papers, internet databases and textbooks. Research papers, online databases are nowadays available on-line as open access and provide sufficient and updated information when compared to textbooks. Pharm GKB is a very widely used website for PGx education (Karas Kuželički, *et al*., 2019).

After the successful completion of the Human Genome Project, the Food and Drug Administration (FDA) modified the prescribing information of the oral anticoagulant: Warfarin based on genomic evidence to improve the safety of patients receiving anticoagulants. The FDA also came up with a web page indicating pharmacogenomic data for over 130 medications. Examples for drugs like cetuximab, panitumumab, bosutinib, crizotinib, abacavir, and vemurafenib pharmacogenetic testing is recommended before initiating therapy. Clinical Pharmacogenetics Implementation Consortium (CPIC) has established clinical guidelines to guide physicians with recommendations for patients. These guidelines are widely available online through Pharmacogenomics Knowledge Base (PharmGKB) website and also as open-access in the journal, Clinical Pharmacology and Therapeutics. Access to prescribing information and guidelines based on PGx can be useful in pharmacogenomic education.

Another essential component is improving the clinical practice in this area. Pharmacists realize the scope of pharmacogenomics, but lack the confidence and skills to implement it into practice. Several educational reforms may be necessary to bridge the gap between theory and practice. CAPE 2013 demonstrates the essential competencies for pharmacists in the area of personalized medicine, including knowledge and abilities as a learner, caregiver, manager, promoter, provider, problem solver, educator, collaborator, includer, communicator and innovator. These outcomes reflect the necessary knowledge and skills for graduating pharmacists.

Practical training is needed to immerse students in the process of fetching genetic sample from patients, analyzing the genetic data, and translating the genetic information into clinical recommendations. Several institutions use exercises such as these to raise students' awareness of pharmacogenomics applications.

The basic concepts of pharmacogenomics can be taught and assessed using the traditional teaching strategies, but the improvement in knowledge and skills required to make clinical recommendations

require case-based and evidence-based training. Comprehensive medication management and precision medicine is definitely the future of pharmacy practice. It is of extreme importance that pharmacy students learn how to apply pharmacogenomic data to optimize therapeutic outcomes. In the decades to come, patients will be able to test their genomic profile, which in turn will be integrated into their health records to provide physicians with genomic data to assist in planning out the optimal therapeutic plan for a patient.

Teaching of pharmacogenomics in clinical settings should involve innovative teaching-learning strategies. Students may be asked to develop a clinical action plan which would require taking into account clinical, financial, laboratory, administrative, and the feasibility of implementing the plan (Kisor, *et al*., n.d.). Sessions with lecture time and activities can be designed to improve the learning and applicability of pharmacogenomics to pharmacy practice. At the end of the teaching session, student learning can be assessed with quizzes, questionnaires, group activities (Szklarz, Geldenhuys, & Lockman, 2018).

Some of the strategies for improving clinical Pharmacogenomics education (Figure 1) may include providing support for pharmacogenomics education in basic pharmacy curriculum, promote development of postgraduate pharmacogenomic studies, develop and provide tailored educational resources for young pharmacists with a variety of knowledge, application, and practice-based continuing education programs and certificate courses, liaison with other healthcare professionals and organizations to promote interdisciplinary education (D, *et al*., 2019).

Pharmacy schools could include, basic genetics course as a preadmission requirement. Student seeking admission into a pharmacy course must be required to complete a basic level course on genetics. Pharmacy colleges can integrate a pharmacogenomics course along side the PharmD curriculum. Pharma institutions must provide specially set-up pharmacogenomics laboratories and provide for research training to PharmD students in the area of pharmacogenomics. Furthermore institutions must recruit faculty with experience and specialization in pharmacogenomics to teach and train students (Rao & Rao, 2015).

Training the faculty in the line of pharmacogenomics could be an effective step towards improving student education. Online teaching appears to be a feasible strategy for training pharmacy students as well as faculty in the area of pharmacogenomics (Lee, Ma, Hudmon, & Kuo, 2012).

New supplemental courses on PGX can be designed and implemented for pharma students (Brazeau & Brazeau, 2006). Pharmacogenomics course could include definition of common terms and nomenclature used in PGx, comparing different PGx study designs, understanding the effects of variation in gene structure and their expression on PK/PD, demonstrating how genetic variation in a large number of proteins can influence pharmacokinetics and pharmacodynamics and drug response, understanding the influence of polymorphisms with drug response, using online resources to predicted drug response from genetic data, developing a step-wise decision-making process for the integrating PGx with knowledge on PK/PD to make recommendations for patients, using evidence-based guidelines relevant to pharmacogenomic testing in order to select the drug therapy, illustrating the use of PGx in clinical situations, evaluating and understanding the potential benefits, limitations, and risks of genetic testing for individuals and Understanding the ethical, legal, and social issues related to PGx (Adams, *et al*., 2016).

Providing unique experimental and research opportunities for pharmacy students can adequately develop a number of core competencies in pharmacogenetics. Special emphasis should be given to the genetic basis of diseases; drug discovery and disposition, drug target identification; ethical aspects, social and economic implications (Drozda, *et al*., 2013).

Building relationship with industries, communication of advancements, general education for the public, interprofessional education, updating the curricula, developing competencies, roles for practice and a common platform for reporting and communicating, providing access to information and PGx tools, promoting innovations, funding for PGx studies and services, wider distribution of FDA labeling updates relevant to PGx, assessment of pharmacy education programs regarding PGx, developing a system of electronic formats to aid pharmacists in relevant practices and engaging pharmacists in ongoing interdisciplinary efforts to educate health professionals can facilitate pharmacogenomic education (Feero, Kuo, Jenkins, & Rackover, 2012).

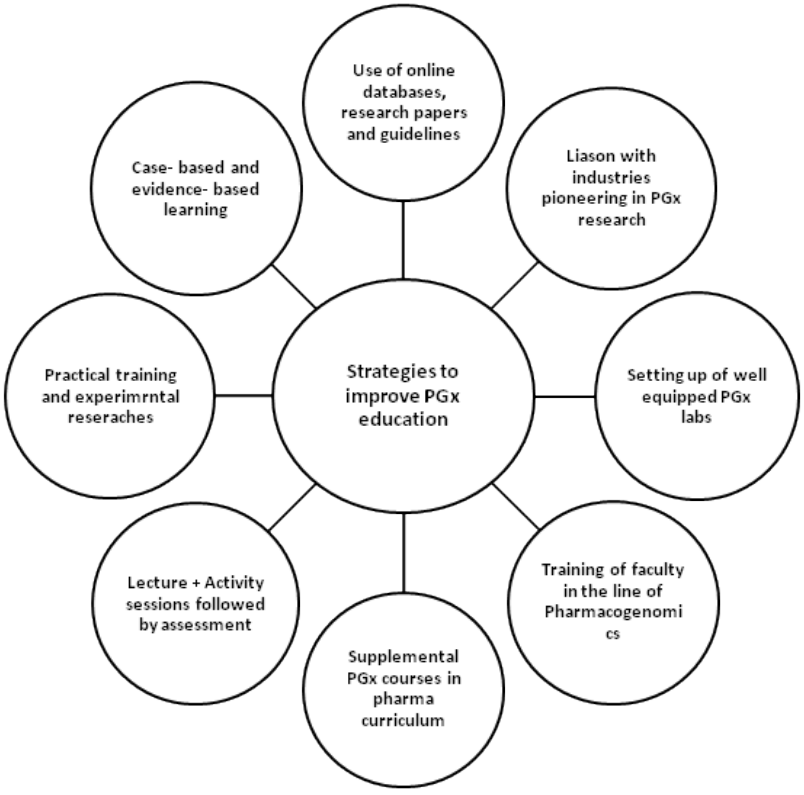

Figure 1: Strategies to Improve Pharmacogenomic Education

4. Conclusion

MIt is true that in the future, personalized treatment would uplift the standards of drug treatment, but the prime factors to be pondered upon are its availability, affordability and its impact on health. Concerns regarding medical, ethical, societal, and regulatory aspects of pharmacogenomics and its implementation into the clinical practice do exist. Dedications to bioethics and societal aspects of pharmacogenomics are underway. More emphasis to implementation and upliftment of pharmacogenomic education in pharma education is necessary as it would be of great potential in the upcoming years.

Conflict Of Interest

The Author(s) declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Adams, S. M., Anderson, K. B., Coons, J. C., Smith, R. B., Meyer, S. M., Parker, L. S., & Empey, P. E. (2016). Advancing Pharmacogenomics Education in the Core PharmD Curriculum through Student Personal Genomic Testing, 80(1).
2. Awaisu, A. (2019). Pharmacogenomics In Pharmacy Practice : Current Perspectives.
3. Brazeau, D. A., & Brazeau, G. A. (2006). INSTRUCTIONAL DESIGN AND ASSESSMENT A Required Course in Human Genomics, Pharmacogenomics, and Bioinformatics, 70(6), 1–6.
4. D, J. K. H. P., Ph, D., D, H. M. D. P., D, R. S. F. P., Ph, D., D, D. R. B. P., … D, J. C. L. P. (2019). Precision pharmacotherapy : Integrating pharmacogenomics into clinical pharmacy practice, (April), 303–313. https://doi.org/10.1002/jac5.1118
5. Daly, A. K. (2017). Pharmacogenetics: A general review on progress to date. British Medical Bulletin, 124(1), 65–79. https://doi.org/10.1093/bmb/ldx035
6. Drozda, K., Labinov, Y., Jiang, R., Thomas, M. R., Wong, S. S., Patel, S., … Cavallari, L. H. (2013). INSTRUCTIONAL DESIGN AND ASSESSMENT A Pharmacogenetics Service Experience for Pharmacy Students, Residents, and Fellows, 77(8).
7. Feero, W. G., Kuo, G. M., Jenkins, J. F., & Rackover, M. A. (2012). Pharmacist education in the era of genomic medicine. Journal of the American Pharmacists Association, 52(5), e113–e121. https://doi.org/10.1331/JAPhA.2012.12149
8. Gurwitz, D., Lunshof, J. E., Dedoussis, G., Flordellis, C. S., Fuhr, U., Kirchheiner, J., … Wong, S. (2005). Pharmacogenomics education: International Society of Pharmacogenomics recommendations for medical, pharmaceutical, and health schools Deans of Education. Pharmacogenomics Journal, 5(4), 221–225. https://doi.org/10.1038/sj.tpj.6500312
9. Karas Kuželički, N., Prodan Žitnik, I., Gurwitz, D., Llerena, A., Cascorbi, I., Siest, S., … Marc, J. (2019). Pharmacogenomics education in medical and pharmacy schools: Conclusions of a global survey. Pharmacogenomics, 20(9), 643–657. https://doi.org/10.2217/pgs-2019-0009
10. Kisor, D. F., Smith, H., & Grace, E. (n.d.). The DNA of Pharmacy Education : CAPE Outcomes and Pharmacogenomics Table of Contents. American Association of Colleges of Pharmacy Center for the Advancement of Pharmacy Education Outcomes. Retrieved from https://www.aacp.org/sites/default/files/2017-10/The_DNA_of_Pharmacy_Education-CAPE_Outcomes_and_Pharmacogenomics_2015.pdf
11. Lee, K. C., Ma, J. D., Hudmon, S., & Kuo, G. M. (2012). A Train-the-Trainer Approach to a Shared Pharmacogenomics Curriculum for US Colleges and Schools of Pharmacy, 76(10), 1–8.
12. Marcinak, R., Paris, M., & Kinney, S. R. M. (2018). Pharmacogenomics Education Improves Pharmacy Student Perceptions of Their Abilities and Roles in Its Use. American Journal of Pharmaceutical Education, 82(9), 6424. https://doi.org/10.5688/ajpe6424
13. Mccullough, K. B., Formea, C. M., Berg, K. D., Burzynski, J. A., Cunningham, J. L., Ou, N. N., … Nicholson, W. T. (2011). Assessment of the Pharmacogenomics Educational Needs of Pharmacists, 75(3).
14. Meyer, U. A. (2004). Pharmacogenetics – five decades of therapeutic lessons from genetic diversity, 5(September).
15. Pirmohamed, M. (2001). Pharmacogenetics and pharmacogenomics. British Journal of Clinical Pharmacology. https://doi.org/10.1046/j.0306-5251.2001.01498.x
16. Rao, U. S., & Rao, P. S. (2015). Pharmacogenomics Strategies for implementation of an.
17. Riper, V. (n.d.). Knowledge, attitudes and education of pharmacists regarding pharmacogenetic testing R esearch A rticle, 19–27.
18. Schwab, M., & Schaeffeler, E. (2012). Pharmacogenomics: a key component of personalized therapy. Genome Medicine, 4(11). https://doi.org/10.1186/gm394
19. Szklarz, G. D., Geldenhuys, W. J., & Lockman, P. R. (2018). An Effective Approach to Teaching Pharmacogenomics in the First Year of Pharmacy Curriculum, 82(8). https://doi.org/10.5688/ajpe6345
20. T P, A. (2009). Pharmacogenomics: The Right Drug to the Right Person. Journal of Clinical Medicine Research, 1(4), 191–194. https://doi.org/10.4021/jocmr2009.08.1255
21. Weinshilboum, R. M., & Wang, L. (2017). Pharmacogenomics: Precision Medicine and Drug Response. Mayo Clinic Proceedings, 92(11), 1711–1722. https://doi.org/10.1016/j.mayocp.2017.09.001
22. Weitzel, K. W., Aquilante, C. L., Johnson, S., Kisor, D. F., & Empey, P. E. (2016). Educational strategies to enable expansion of pharmacogenomics-based care. American Journal of Health-System Pharmacy, 73(23), 1986–1998. https://doi.org/10.2146/ajhp160104