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The pharmacist's attitudes and knowledge of pharmacogenomics and the factors that may predict future engagement

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Abstract

The aim of the study is to describe the Pharmacist's attitudes and knowledge of pharmacogenomics and the factors that may predict future engagement. The primary objective of this survey was to determine how post-graduate education and training influences pharmacist's knowledge and attitudes of pharmacogenomic testing**.** In summary, pharmacists with more post-graduate education and training responded more favorably to taking on pharmacogenomic testing. In order to best implement wide-spread testing, pharmacists with post-graduate training could be utilized first as a basis of knowledge for adoption of pharmacogenomics programs. Increased visibility and usage of educational resources will be needed for the majority of pharmacists to have a baseline knowledge of pharmacogenomic testing.

Keywords: Pharmacist's; Attitude; Knowledge; Pharmacogenomics; Predict

1. Introduction

Pharmacogenomics is part of a field called personalized medicine that aims to customize health care, with decisions and treatments tailored to each individual patient in every way possible. Pharmacogenomics deals with new innovations in the field of personalized medicines and innovations in customized drug discovery using proteome technology [1]. It explains about the inherited genetic differences in drug metabolic pathway which can affect individual response to drugs include therapeutic effect as well as adverse effects and also studies various aspects of drug design, drug development and drug delivery [2]. Pharmacogenomics is the branch of medical sciences dealing with the use of DNA and other amino acid sequence data in the process of drug development and testing. It deals with individual genetic variation with drug responses. Pharmacogenomics aims to develop rational means to optimize drug therapy, with regard to the patients' genotype, to achieve maximum efficiency with minimal adverse effects[3]. It is hoped that by using pharmacogenomics, pharmaceutical drug treatments can deviate from what is dubbed as the "one-dose-fits-all" approach. Pharmacogenomic research and implementation have increased in recent years as healthcare moves towards precision medicine. A driving force behind pharmacogenomics are drug-gene interactions that affect the patient's response to a medication and may inform treatment choices [4]. Currently, there are several published guidelines on drug-gene interactions from the Clinical Pharmacogenetics Implementation Consortium (CPIC), which provide specific dosing recommendations with a corresponding level of evidence. Additionally, the Food and Drug Administration (FDA) has published a compiled table of gene-drug interactions of significance. The term pharmacogenomics is often used interchangeably with pharmacogenetics. Although both terms relate to drug response based on genetic

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influences. Pharmacogenomics encompasses a more genome-wide association approach, incorporating genomics and epigenetics while dealing with the effects of multiple genes or even chromosomes on drug response [5]. Pharmacogenomics study the inherited genetic differences in drug metabolic pathways (and other pharmacological principles, like enzymes, messengers and receptors) which can affect individual responses to drugs, both in terms of therapeutic effect as well as adverse effects. Pharmacogenetics in the other hand focuses on single drug-gene interactions taking in count allele genes, dominance and gene polymorphism in order to understand the better use of a drug on a single patient or population [6].

2. Methodology

2.1. Survey development

This survey was developed as a follow-up to a previous survey at the same institution of prescribing primary care clinicians (e.g. MDs, DOs, NPs, and PAs) to ascertain pharmacist's attitudes and knowledge of pharmacogenomic testing. The thirteen-question survey was developed by the study team consisting of two pharmacists with pharmacogenomics expertise, two ambulatory care pharmacists, an acute care pharmacist, a research scientist, a study coordinator, and a pharmacy student [7]. Questions were asked to pharmacists to determine information on their attitudes, comfort level, and knowledge regarding pharmacogenomics. Respondents self-reported gender, year of graduation with highest clinical degree, post-graduate training, board certification, primary practice site, full-time equivalent employment hours, time spent performing different pharmacy-related activities, and their prior pharmacogenomics education [8]. This survey was developed and validated internally by the study team based on experience and expertise, as well as on the previous pharmacogenomics survey administered to prescribing clinicians. The full version of the survey can be found in the supplemental materials.

2.2. Sampling methods

This survey was sent to all pharmacists in a large, multistate health system by pharmacy management through a pharmacy list serve. Study data were collected and managed using REDCapTM electronic data capture tools. The survey link was sent out by email and was open for a total of four weeks [9]. A reminder email was sent out one week prior to the survey closing. Responses were anonymous through an automatically generated participant ID in REDCapTM.

2.3. Data analysis

Survey results were compiled into data tables with frequencies for each survey question. Frequencies were stratified based on demographic parameters to determine differences between rural and urban pharmacists, year of graduation, post-graduate training, practice area, and previous education in pharmacogenomics. Chi-squared tests were used to test statistical significance between groups analyzed [10]. Nominal logistical regression was used to assess demographic and pharmacy training factors associated with survey responses. Statistical significance was defined as p-value.

3. Results

The survey was distributed to a total of 161 pharmacists with 75 (47%) completing all aspects. No surveys were returned incomplete. Complete demographic information of survey respondents is listed in Table 1. Of the respondents, 60.3% were female and 39.7%. For post-graduate training and education, 40% of respondents completed a Post-Graduate Year One (PGY-1) residency and 27% were board certified. Of 19 pharmacists that are board certified. Eighty percent of respondents worked a fulltime equivalent (FTE) and 85% worked in an urban area.

Table 1 Demographics of respondents

Demographics of respondents	**N (%)**	
Gender	Female	44 (60.3)
	Male	29 (39.7)
	Not Reported	2 (2.7)
Did you receive post graduate training?	Yes	30 (40)
	No	45 (60)

What type of post graduate training did you receive?	PGY-1	27 (90)
	PGY-2	0 (0)
	Fellowship	2 (6.7)
	Other	2 (6.7)
Do you have a Board Certification?	Yes	20 (26.7)
	No	55 (73.3)
Current Practice Site Based on RUCA Score*	Rural	10 (15.2)
	Urban	56 (84.8)
	Not Reported	9 (12)
Current FTE	Full-time	60 (80)
	Part-time	15 (20)
Primary Practice Setting	AmbulatoryCare Clinic	18
	Outpatient Pharmacy	13
	Acute Care Pharmacy	43
	Clinical Management	3
	OperationsManagement	5
	Other (i.e home health/infusion pharmacies, nuclear, telephone, or mail service, etc.)	5

The majority of respondents (75%) had not received any formal training or education on pharmacogenomics. Of those that had received formal training or education, the most common method was through their school curriculum. When asked about current knowledge of pharmacogenomic resources and guidelines, over half (58%) did not feel knowledgeable. Most respondents indicated they would consult drug resources (64%) and colleagues with expertise (52%) when interpreting pharmacogenomic test results.

Survey questions and responses are listed in Table 2. Nearly 20% of pharmacists recalled a patient or provider bring them a pharmacogenomic test result for consult on dosing recommendations or medication selection; however, 65% stated they were uncomfortable recommending pharmacogenomic tests to providers and patients. When asked about interpreting results of a pharmacogenomic test, 62% were uncomfortable. Furthermore, 59% of respondents felt uncomfortable providing recommendations to a provider or patient based on pharmacogenomic test results and 58% of pharmacists were unsure on where to best document pharmacogenomic test information in a patient's electronic medical record.

Fifty-seven percent of pharmacists felt that pharmacogenomics does have a significant impact on current practice. Additionally, 89% of respondents supported a clinical decision support tool to alert them to potential drug-gene interactions while the other 11% were unsure. When asked about barriers to implementation of pharmacogenomic testing, education (88%) and limited resources (77%) were the two biggest factors noted. In total, 58% of pharmacists surveyed agreed that pharmacists are the best suited clinicians to implement pharmacogenomic testing, while 39% percent were unsure.

Table 2 Survey questions and responses of pharmacogenomics

Survey questions and responses	**N**	**%**
Have you received any formal training or education on pharmacogenomics?	Yes	18 (24)
	Unsure	1 (1.3)
	No	56 (74.7)

How comfortable do you feel recommending pharmacogenomic tests to providers and patients?	Very comfortable	5 (6.7)
	Somewhat comfortable	12 (16)
	Neither comfortable nor uncomfortable	9 (12)
	Somewhat uncomfortable	21 (28)
	Very uncomfortable	28 (37.3)
How comfortable are you interpreting the results of a pharmacogenomic test?	Very comfortable	4 (5.3)
	Somewhat comfortable	15 (20)
	Neither comfortable nor uncomfortable	10 (13.3)
	Somewhat uncomfortable	16 (21.3)
	Very uncomfortable	30 (40)
How comfortable do you feel providing recommendations to a provider or patient based on pharmacogenomic results?	Very comfortable	4 (5.3)
	Somewhat comfortable	12 (16)
	Neither comfortable nor uncomfortable	15 (20)
	Somewhat uncomfortable	18 (24)
	Very uncomfortable	26 (34.7)
How would you assess your current knowledge of pharmacogenomic resources and guidelines?	Knowledgeable	5 (6.7)
	Somewhat knowledgeable	23 (30.7)
	Notknowledgeable	44 (58.7)
	Unsure	2 (2.7)
	Not reported	1 (1.3)
Which sources would you consult when interpreting pharmacogenetic test results?	Medical Association Meetings/ Guidelines/ Recommendations	29 (38.7)
	Scientific Literature	35 (46.7)
	Drug Resources (e.g. Micromedex, Lexicomp, etc.)	48 (64)
	Internet	21 (28)
	Drug Labeling / FDA website	22 (29.3)
	Colleague with expertise	39 (52)
	Other	6 (8)
Has a patient or provider brought a pharmacogenomic test result to you for guidance in medication dosing or selection or to explain previous medication experiences?	Yes	12 (16)
	Unsure	2 (2.7)
	No	61 (81.3)
How significant of an impact do you believe pharmacogenomics has on current practice?	Very significant	12 (16)
	Somewhat significant	31(41.3)
	Neither significant nor insignificant	10(13.3)
	Somewhat insignificant	14 (18.7)
	Very insignificant	8 (10.7)
	Enter notes into electronic health record	25(33.3)
	Scan test results into the electronic health record	24 (32)

How would (have) you document (ed) pharmacogenomic test results in a patient's electronic medical record?	List major findings as an allergy	14 (18.7)
	List major findings in the problem list	13 (17.3)
	Flagging a medication that has CPIC guidance	10 (13.3)
	Unsure	44 (58.7)
	Other	5 (6.7)
Do you support offering pharmacogenomic testing and interpretation though Pharmacy Services?	Yes	54 (72)
	Unsure	19 (25.3)
	No	2 (2.7)
Would you want a decision support tool to alert you to potential drug-gene interactions in patients with pharmacogenomic results?	Yes	67 (89.3)
	Unsure	8 (10.7)
What barriers do you think are preventing/slowing the implementation of pharmacogenomic services?	Insurance	44 (58.7)
	Willingness to take on a new task	23 (30.7)
	Education Process of ordering to putting in the medical record Limited resources for interpretation and application of pharmacogenomic test	66 (88)
Do you agree with the following statement: Pharmacists are the best suited clinicians to implement pharmacogenomic testing.	Yes	44 (58.7)
	Unsure	29 (38.7)
	No	2 (2.7)
If yes, where within the practice of pharmacy is pharmacogenomics the best suited?	Acute and Ambulatory	2 (5.4)
	Ambulatory Care	17 (45.9)
	Clinical Pharmacists	7 (18.9)
	Multiple areas of pharmacy	3 (8.1)
	Specialists that achieved certification	1 (2.7)
	Specialty Clinics (behavioral health, oncology, neurology, cardiovascular)	6 (16.2)
	Unsure	1 (2.7)

Those that completed a PGY-1 were significantly more likely to have received formal training or education on pharmacogenomics than those who had not ($p=0.02$), and assessed their own knowledge of pharmacogenomic resources and guidelines higher than those without a PGY-1 ($p=0.03$). More recent graduates were significantly more likely to have received formal training or education on pharmacogenomics ($p<0.0001$). Female respondents were significantly more likely to be supportive of pharmacogenomic testing and interpretation through pharmacy services as compared to males ($p=0.005$), and were also more likely to have graduated ($p=0.001$). Additionally pharmacists who completed a PGY-1 residency were more likely to respond favorably to pharmacogenomics being offered through pharmacy services ($p=0.01$) and a decision support tool to alert them to drug-gene interactions ($p=0.04$) as compared to pharmacists with out PGY-1 training. In the same comparison, they also agreed pharmacists are the best suited clinician to implement pharmacogenomic testing ($p=0.01$). Year of graduation was independently associated with receipt of formal PGx training ($p<0.01$), while gender ($p=0.99$) and PGY1 training ($p=0.61$) was not. Female gender was independently associated ($p=0.02$) with supporting PGx service through pharmacy services and those with PGY-1 training were also more likely to be supportive; however, this did not meet significance ($p=0.12$). Year of graduation, gender and PGY-1 training was not associated with agreement that pharmacists are the best suited clinicians to implement PGx testing.

4. Discussion

In general, pharmacists surveyed reported pharmacogenomic testing to have a somewhat or very significant impact on current practice. In spite of this, only 58% thought pharmacists were the best suited clinician to implement pharmacogenomic testing into practice. Consistent with prior surveys, the biggest barriers to implementation were identified as limited resources and education, supported by the finding that most pharmacists do not feel comfortable ordering or interpreting a pharmacogenomic test and would need additional education. Most notably, pharmacists with more postgraduate training (e.g. residency or board certification) were more comfortable in interpreting and recommending results as compared to those without, while no respondents were against a clinical decision support tool to aid in identifying drug-gene interactions. Post-graduate education and training was also associated with more knowledge and comfort in pharmacogenomics testing. To the best of our knowledge, this is the first survey to assess the impact of post-graduate education and training on attitudes and knowledge of pharmacogenomic testing amongst pharmacists. Although most pharmacists surveyed felt that they are the best suited clinicians to implement pharmacogenomic testing, a surprisingly high number were unsure. In our previous survey, The primary care clinicians were interested in pharmacogenomics testing being available through the Medication Therapy Management Program, which is consistent with the responses of pharmacists herein. The uncertainty pharmacists have in implementing pharmacogenomics in their own practice may be due to inadequate education and will need to be further discussed to ensure that pharmacists are confident in this field prior to implementation. Of note, acute care pharmacists, a number of whom completed this survey, may recognize the importance of pharmacogenomics but not feel that it should be emphasized in their setting as much as ambulatory care. Additionally, pharmacists working as generalists, who made up the majority of the respondents herein, may not see as great of an impact as a specialist on the need to be knowledgeable in pharmacogenomics. According to AACP, PharmD graduates were female, which was consistent with the demographics seen in this survey. Interestingly, female respondents were more likely than males to be supportive of pharmacogenomic testing and interpretation through pharmacy services. The results of this survey are similar to previous findings amongst hospital pharmacists regarding pharmacogenomic testing. Previous surveys found that most pharmacists believed that pharmacogenomics will benefit their patients. Those pharmacists were also interested in continuing education, as they lacked confidence in their ability to use pharmacogenomic information. The variable most likely predict a pharmacist's adoption of pharmacogenomics into their practice was confidence in their ability to counsel patients on their test results. Similar to the reported survey, primary care clinicians have also reported that pharmacy services should take on the role of implementing pharmacogenomics, specifically in the ambulatory care setting. They similarly supported a clinical decision support tool and more education regarding pharmacogenomic testing. An additional study in the Netherlands found that despite having a clinical decision support tool containing the nationwide guidelines, implementation of pharmacogenomics was less than expected because pharmacists did not feel adequately informed on pharmacogenomics. Although clinical decision support impacts usability of pharmacogenomic information in the medical record, without basic education on pharmacogenomics it may not have a meaningful impact on implementing testing.

More recent graduates reported more education in pharmacogenomics than more experienced pharmacists, possibly as a result of recent requirements to include didactic pharmacogenomic educational elements within pharmacy school curriculums. However, survey participants who had completed a PGY-1 noted greater comfort with pharmacogenomics, while no differences were seen with year of graduation and level of comfort with pharmacogenomics. Per the most recent accreditation standards set by ASHP for PGY-1 Residencies, there are no specific requirements for education on pharmacogenomic testing. The increased comfort seen with pharmacists that completed a PGY-1 may be due to other factors associated with completing a residency such as experience in specialty areas and not the residency itself, suggesting that more practice-based experiences may be needed to increase pharmacists comfort level with pharmacogenomics. For pharmacists already in practice, there are numerous pharmacogenomics certificate programs administered by pharmacy associations, health systems and colleges of pharmacy to help pharmacists increase their knowledge in this area. Other continuing education and site-specific trainings can also aid in pharmacists obtaining competencies in pharmacogenomics. For example, a pharmacogenomics educational program developed at the Mayo Clinic to educate their pharmacists was well received, showed a positive influence in pharmacy practice, and a significant increase in competency based on a pre and posttest on pharmacogenomics. Perhaps the most effective method of retaining pharmacogenomics education is practice-based application of pharmacogenomic concepts. Pharmacogenomic certificate training programs have been shown to raise pharmacist's perceived competence related to specific drug-gene interactions in simulated patient encounters. Traditional continuing education methods have proved to not be as effective since it has been shown that pharmacists don't change their behaviors afterwards. This study was limited by several factors. First, the distribution of pharmacists responding to the survey was not uniform, as the majority came from more urban areas and not all pharmacies in the health-system were represented. Second, the survey was localized to one health-system and not externally validated. Finally, while there were respondents representing several practice areas of pharmacy, the majority of respondents practiced in the acute care setting.

5. Conclusion

In summary, pharmacists with more post-graduate education and training responded more favorably to taking on pharmacogenomic testing. In order to best implement wide-spread testing, pharmacists with post-graduate training could be utilized first as a basis of knowledge for adoption of pharmacogenomics programs. Increased visibility and usage of educational resources will be needed for the majority of pharmacists to have a baseline knowledge of pharmacogenomic testing.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest, financial or otherwise.

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