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Pharmacy students’ attitudes and perceptions toward pharmacogenomics education

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Pharmacy students' attitudes and perceptions toward pharmacogenomics education

Abstract

Purpose

To evaluate final-year pharmacy students' perceptions toward pharmacogenomics education, their attitudes on its clinical relevance, and their readiness to use such knowledge in practice.

Methods

A 19-question survey was developed and modified from prior studies and was pretested on a small group of pharmacogenomics faculty and pharmacy students. The final survey was administered to 978 final-year pharmacy students in 8 school/colleges of pharmacy in New York and New Jersey between January and May 2017. The survey targeted 3 main themes: perceptions toward pharmacogenomics education, attitudes toward the clinical relevance of this education, and the students' readiness to use knowledge of pharmacogenomics in practice.

Results

With a 35% response rate, the majority (81%) of the 339 student participants believed that pharmacogenomics was a useful clinical tool for pharmacists, yet only 40% felt that it had been a relevant part of their training. Almost half (46%) received only 1–3 lectures on pharmacogenomics and the majority were not ready to use it in practice. Survey results pointed toward practice-based trainings such as pharmacogenomics rotations as the most helpful in preparing students for practice.

Conclusions

Final-year student pharmacists reported varying exposure to pharmacogenomics content in their pharmacy training and had positive attitudes toward the clinical relevance of the discipline, yet they expressed low confidence in their readiness to use this information in practice.

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Title:

Final Year Student pharmacists' attitudes and perceptions towards pharmacogenomics education and their readiness to adopt it in their practice

Abstract:

Purpose: To evaluate final year pharmacy students' perceptions towards pharmacogenomics education; their attitudes on its clinical relevance; and their readiness to use such knowledge in practice.

Methods: A 19-question survey was developed and modified from prior studies and was pretested on a small group of pharmacogenomics faculty and pharmacy students. The final survey was administered to 978 final year pharmacy students in eight school/colleges of pharmacy in New York and New Jersey between January and May 2017. The survey targeted three main themes: perceptions toward pharmacogenomics education, attitudes towards the clinical relevance of this education and the students' readiness to use knowledge of pharmacogenomics in practice.

Results: With a 35% response rate, the majority (81%) of the 339 students participants believed that pharmacogenomics is a useful clinical tool for pharmacists yet only 40% felt that it had been a relevant part of their training. Almost half (46%) received only 1 – 3 lectures on pharmacogenomics and the majority are not ready to use it in practice. Survey results pointed towards practice-based trainings such as pharmacogenomics rotations as the most helpful in preparing students for practice.

Conclusions: Most of the final year student pharmacists had some exposure to pharmacogenomics content in their training and positive attitudes towards the clinical relevance of the discipline; however an overwhelming majority expressed low confidence in their readiness to utilize this information in practice. Hence, practice-based training opportunities taught by well-trained faculty may be needed to prepare future pharmacists in this discipline.

Introduction

Pharmacogenomics is the study of how an individual's genome can influence his or her response to drugs.(1) To date, over 200 FDA-approved medications have pharmacogenomics product-label changes and polymorphisms in genes that encode drug-metabolizing enzymes make up 80% of these product label updates.(2) However, widespread adoption into clinical practice has been lagging behind the technological advances and research discoveries.

For decades, pharmacists have played pivotal roles in health care to optimize drug therapy while minimizing and/or preventing adverse drug events. Pharmacists' extensive knowledge of pharmacotherapy and their skillsets in therapy optimization uniquely positions them to assume key functions and leadership in the clinical implementation of pharmacogenomics.(3) The 2015 American Society of Health-System Pharmacists (ASHP) statement on the *Pharmacist's Role in Clinical Pharmacogenomics* not only affirmed the esteemed professional society's support of pharmacogenomics but it also highlighted five responsibilities of pharmacists in this specialty. Advocating for the rational and routine use of pharmacogenomics testing, providing test results interpretation; and educating providers and patients on clinical application of pharmacogenomics are few of the aforementioned roles of pharmacists.(4)

In a survey of 303 pharmacists, 65% believed that pharmacists need to be knowledgeable about the appropriate use of pharmacogenomics testing however, nearly the same number of respondents felt inadequately prepared to use the results of pharmacogenomics tests in practice.(5) This sentiment has been reported by others as well.(6-9) Reports in 2005 demonstrated that only 39% of pharmacy schools included pharmacogenomics content in their curricula.(10) Fast forward to 2010, and Murphy et al reported an impressive improvement with

90% of schools reporting curricula adoption of pharmacogenomics content.(11) In the Murphy report, the authors also reported varying degrees of content coverage among the schools and more than half had no plans for faculty development in pharmacogenomics.(11)

The marked increase in the number of pharmacy schools with pharmacogenomics training may be attributed to the efforts of the Accreditation Council for Pharmacy Education (ACPE) and the American Association of Colleges of Pharmacy (AACP) since the 2005 report. The ACPE issued pharmacogenomics content requirements for all pharmacy schools effective July 2007.(12) Moreover, the 2008 AACP House of Delegates approved resolutions that called for training and curricula modifications to address implications of personalized medicine and biotechnology as well as tailored faculty training in these disciplines.(13)

It has been a decade since the initial recommendation to focus on pharmacogenomics training in our schools of pharmacy and as such we sought to investigate how the educational strategies and increased training have affected the newly graduating pharmacists. The objective of this study was to assess 2017 final year pharmacy students' perceptions and attitudes on pharmacogenomics and their readiness to incorporate it into their practice as pharmacists.

Methods

Survey Participants

All eleven schools/colleges of pharmacy in New York, New Jersey and Connecticut were invited however three schools did not respond and were therefore excluded from the study. The eight schools that participated are Albany College of Pharmacy and Health Sciences, Touro College of Pharmacy, St. John Fisher College Wegmans School of Pharmacy, D'Youville College School of Pharmacy, Fairleigh Dickinson University, St. John's University, Long Island University Arnold

& Marie Schwartz College of Pharmacy and University at Buffalo School of Pharmacy and Pharmaceutical Sciences. The appropriate Human Subjects Protection Program Institutional Review Board approvals were granted to all participating schools. In all, 978 final year students (Class of 2017) were eligible to participate in the survey.

Design

This was a descriptive study that employed a 19-question survey developed and modified from prior studies (11, 14) to assess participant demographics and three main themes: (1) the students' attitudes towards pharmacogenomics education; (2) their perceptions on the clinical relevance of pharmacogenomics; and (3) their readiness to adopt it into their practice. A five-point likert-scale ranging from strongly agree to strongly disagree was used to score the responses. A pretest of the survey tool was conducted with four academic pharmacists involved in pharmacogenomics research and didactic training as well as three pharmacy students undergoing pharmacogenomics advanced pharmacy practice experiential (APPE) rotation. All "pre-testers" provided feedback on content, length, clarity and utility of the survey tool which was then used to refine the final set of questions. Additionally, the authors reviewed and approved the questionnaire before it was administered. The survey was administered electronically via www.surveymonkey.com between January and May 2017 and faculty-student champions from each of the participating schools deployed the link to the questionnaire to the graduating class of their respective schools. The participants were given 8 weeks to complete the survey initially. After that, the deadline for completion was extended for an additional four weeks. Two reminder emails were sent by the faculty-student champions in four week intervals.

Moreover, the faculty champions provided additional information on their respective schools and the nature of the PGx courses offered.

Statistical Analysis

Survey data was collected using surveymonkey.com and interpreted using a range of descriptive statistical methods, such as cross-tabulations, comparisons of means and standard deviations across multinomial variables, and data visualization. Ordinal logistic regression was used to estimate the overall main effects of certain demographic predictors, which were converted to ordered categorical variables, on the survey response outcomes. All statistical analyses were conducted in SPSS 23 and R.

Results

Student Demographics

Of 978 students eligible for the study, 339 (35%) students completed the survey. **Table 1** summarizes the relevant demographics. The respondents were mostly females (n= 213, 63%). A majority were between the ages of 21 and 25, (n=194, 57%) and 26 and 30 years (n =106, 31%). High school was the most common educational level completed by the respondents prior to matriculating to pharmacy school as reported by 147 (43%) students and 158 (47%) plan to pursue community pharmacy opportunities post-graduation.

Description of the Pharmacogenomics Educational Opportunities at the Participating Schools

As shown in **Table 2**, pharmacogenomics is integrated through other courses at two schools; offered as a standalone course in four schools and as both integrated and standalone in the remaining two schools of pharmacy. Of those with standalone courses, four require it for all their students and two offer it as an elective class. Notably, only two PGx faculty members have been formally trained in pharmacogenomics, while others have undergone varying degrees of training. The learning objectives differ across schools and an elective PGx APPE rotation is available to students from three of the participating schools.

Exposure to pharmacogenomics education

The respondents were queried on their exposure to pharmacogenomics content in their pharmacy school curricula (**Figure 1**). One hundred and fifty-six (46%) were exposed to 1 – 3 pharmacogenomics lectures, 96 (28%) completed a required pharmacogenomics course, 20 (6%) took an elective pharmacogenomics course, 8 (2%) completed a pharmacogenomics APPE rotation, 39 (12%) did not receive any pharmacogenomics training and 19 (6%) did not respond to this question.

Perception on the Clinical Relevance of Pharmacogenomics

Four questions were posed to investigate the perceived clinical utility and relevance of pharmacogenomics among the final year student pharmacists (**Table 3**). Majority (81%, n=273) believed that pharmacogenomics is a useful tool that pharmacists and medical professionals can use to optimize medication efficacy and/or prevent adverse events and more than half (63%, n=234) affirmed that it is an integral part of the pharmacy profession. Sixty-one percent (n=205) perceived that pharmacogenomics may be an integral part of their practice as pharmacists and slightly more (69%, n=234) predicted that they may encounter pharmacogenomics-related questions during their practice as pharmacists.

Attitudes towards pharmacogenomics education

Approximately seventy-one percent (n = 239) of the respondents believe that pharmacogenomics should be covered in detail in all schools and colleges of pharmacy; however, only 40% (n=136) felt that it had been a relevant part of their Doctor of Pharmacy curriculum. Moreover, 51% (n=175) agreed that final year pharmacy students should be required to have substantial knowledge of pharmacogenomics prior to graduation and 56% (n=188) indicated their intentions of reading pharmacogenomics-related literature post-graduation especially those that pertain to their respective practices and specialties (**Table 2**).

The students' past exposure to pharmacogenomics training content was significantly associated with their attitudes towards pharmacogenomics education. Pharmacogenomics training (**Figure 1**) was converted into an ordered categorical variable, with the lowest level being no exposure to pharmacogenomics in pharmacy school (n = 39), followed by 1-3 lectures or seminars (n=156), elective pharmacogenomics course (n=20), required pharmacogenomics course (n=96), and finally the highest level being pharmacogenomics APPE rotation (n= 8). This measure of pharmacogenomics training was significantly associated with more agreement to three of the four questions assessing attitudes towards pharmacogenomics education (Figure 2).

Readiness to Use Pharmacogenomics Knowledge in Practice

As proposed by the ASHP (4), pharmacists should know medications with pharmacogenomics implications, the associated tests and their interpretations as well as recommended therapeutic modifications for genetically "high-risk" individuals. To this end, we asked the final year student pharmacists if they knew at least ten medications that the FDA either requires or recommends pharmacogenomics testing prior to use (**Table 3**). Only 32% (n=108) responded affirmatively while 44% (n=150) did not know at least ten of such medications. Furthermore, when queried on their ability to recommend the appropriate pharmacogenomics tests for the medications that require it, only 21% (n=72) stated they could and about a third (27%, n=91)) reported having the ability to accurately interpret pharmacogenomics tests. Again, 32% (n=107) felt knowledgeable to recommend alternative therapies and/or dose changes based on pharmacogenomic results.. Lastly, 62% (n=209) were not aware of the Clinical Pharmacogenetics Implementation Consortium's (CPIC) guidelines which provide a clinical recommendations to clinicians on how to use genetic information to guide medication selection and dosing.(15)

As expected, the students' past exposure to pharmacogenomics content in their curricula was strongly associated with increased agreement with the statements about readiness to use pharmacogenomics in practice (**Figure 3**). More exposure to pharmacogenomics was correlated with the students' knowledge of at least ten medications needing pharmacogenomic testing (β=0.349, 95% CI: 0.231-0.468); their ability to recommend appropriate pharmacogenomic tests for such medications (β=0.251, 95% CI: 0.128-0.375); their ability to accurately interpret these tests (β=0.363, 95% CI: 0.244-0.482); their knowledge of the appropriate therapeutic recommendations based on the pharmacogenomics test results (β =0.342, 95% CI: 0.237-0.448); and their awareness of CPIC guidelines (β=0.313, 95% CI: 0.206-0.420).

Discussion:

Clinical applications of pharmacogenomics are increasingly gaining acceptance as evidenced by the National Institutes of Health National Human Genome Research Institute (NIH/NHGRI) – funded consortia focused on developing tools and clinical implementation strategies (16-18) and the availability of databases such as the FDA Table of Biomarkers(19) and the Pharmacogenomics Knowledge Base: www.pharmgkb.org(20).

Pharmacists are distinctively qualified medical professionals to lead translational pharmacogenomics and assume essential roles in its education and sustained adoption in professional curricula (3). Of the 339 participants in this study, 82% had been exposed to pharmacogenomics content in varying degrees throughout their pharmacy school program ranging from 1 – 3 lectures to several weeks of pharmacogenomics APPE rotation experience. This finding sadly affirms the 2010 study by Murphy et al., in which 67 (89%) colleges/schools of pharmacy reported having pharmacogenomics content in their doctor of pharmacy curricula albeit the dedicated didactic hours differed greatly from school to school (11). In that study, 28 schools (41%) dedicated 10 or fewer hours, while 29 (42%) reported 11 to 30 didactic hours for pharmacogenomics. A decade later, Murphy et al.'s findings still resonate as demonstrated in the present study. Almost half of the final year students in our survey (46%) encountered pharmacogenomics content in 1 – 3 lectures, and approximately 12% received no pharmacogenomics instruction throughout their pharmacy school tutelage. In all, 40% noted that pharmacogenomics has been a relevant part of their pharmacy training. This is almost a four-fold boost from the 2011 finding by McCullough and colleagues in which only 10% of surveyed pharmacists stated that pharmacogenomics had been a relevant component of their pharmacy education(5).

From this study and others, it is clear pharmacists believe that pharmacogenomics is a relevant tool to optimize patient care however, majority are not comfortable in their abilities to utilize it in their practice (5, 6, 14, 21). The current study and others also confirm that educational opportunities available to student pharmacists in their training may not be sufficient to resolve this issue. Seventy-one percent of the students' believe that it should be covered in detail in pharmacy curricula; 52% state that pharmacists should be required to have substantial knowledge in pharmacogenomics prior to graduation; and 56% intend to continue seeking educational opportunities in this discipline post-graduation. Clearly, a great number of the students want this information.

There are two main reasons for the inadequate training in pharmacogenomics. The first is the lack of well-trained educators to introduce content that addresses core competencies. In our study, 25% of the faculty members were formally trained in pharmacogenomics while the others completed coursework, certificate programs and were exposed through involvement in pharmacogenomics research (**Table 2**). Although a few were clinical faculty, none is actively practicing in pharmacogenomics.

University of California San Diego Pharmacogenomics Education Program (PharmGenEd) (22), University of Pittsburgh's Test2Learn(23), University of Florida (UF) Health Personalized Medicine Program graduate and certificate training program (24) and the University of Colorado Pharmacogenomics Certificate Program (25) are all excellent opportunities for pharmacy school faculty to receive hands-on training in pharmacogenomics either in person or virtually. Some programs provide a shared curriculum that may be adopted in various schools and some use the train-the-trainer methods to provide the best results. In all, these avenues were designed for educators and practitioners who are interested in using pharmacogenomic information in their practice to educate the next generation or optimize patient outcomes respectively. The leadership of colleges of pharmacy should invest in their faculty to participate in these programs especially those who are in charge of providing the didactic lectures on pharmacogenomics. Moreover, faculty members in this position should be aware of the newly updated pharmacogenomics core competencies in pharmacy practice (26) and resources(15, 20) to better instruct their students in the likely event that they encounter examples that may not have been covered in their courses. Of note, CPIC guidelines were unknown to 62% of the respondents in our study which highlights the need for CPIC and other pharmacogenomics resource leaders to consider expanding their reach beyond practicing clinicians to trainees.

Another proposed strategy for overcoming this challenge is to incorporate pharmacogenomics exposure early in the Pharm.D curriculum through the foundational courses and into practice-based therapeutic courses, Introductory Pharmacy Practice Experiences (IPPE) and APPEs.(27) In addition to the learning objectives in **Table 2**, other training content to be considered include but not limited to online resources(28), utilization of electronic health records in pharmacogenomics, potential implications with over-the-counter medications and herbal therapies, reimbursement, and ethical, legal and social issues.

The second challenge is the lack of experiential and practice-based opportunities to engage the students in real-life applications of pharmacogenomics. Formea and colleagues reported marginal retention of educational objectives among practicing pharmacists after two months of providing a fundamental pharmacogenomics education program accredited by ACPE for continued education (29). They concluded that education in this topic area will require more effort to increase knowledge and comfort in dealing with its clinical applications as demonstrated by Galvez-Peralta and colleagues in the School of Pharmacy in West Virginia University(30). . Our findings support this statement and demonstrate that the extent of pharmacogenomics educational exposure and use of practice-based scenarios for teaching may play an important role in preparing the students for the practice setting (31). Final year students who were enrolled in pharmacogenomics APPE rotations were more likely to be prepared to apply pharmacogenomics knowledge in practice than those from the other training methods (Figure 3). To the best of our knowledge, there are two pharmacogenomics APPE rotation opportunities in the New York / New Jersey region; at Mount Sinai (32) and Touro College of Pharmacy; and a handful of others across the country with very limited openings for students annually. Mount Sinai offers an elective rotation to final year student pharmacists from two New

York schools as well as post-graduate year one (PGY1) and post-graduate year two (PGY2) pharmacy residents in the Mount Sinai Health System. Of note, it is a required rotation for PGY2 oncology pharmacy residents at The Mount Sinai Hospital. This training is a combination of topic and patient case discussions, development of clinical decision support content and stakeholder educational tools and personal genotyping. Furthermore, the ASHP Online Residency Directory (https://accred.ashp.org/aps/pages/directory/residencyProgramSearch.aspx) lists three accredited PGY2 clinical pharmacogenomics residencies. With approximately fifteen thousand new graduates annually (33), the training spots identified here are not nearly enough to accommodate the need. School leaderships should make every effort to hire newly trained pharmacogenomics experts into positions that provide both the didactic and the experiential examples for students. Although, establishing a specialty pharmacogenomics residency is not feasible at most institutions, partnering with health systems that are implementing pharmacogenomics(32, 34, 35) and assigning faculty liaisons and/or designing student rotation opportunities may be possible and should be considered.

Furthermore, the strength of the relationship observed between the exposure to pharmacogenomics content and perceived readiness to apply in practice may be limited by the subjective nature of the survey. Also, this project is not in a position to accurately assess whether the responses provided are an accurate representation of the students' knowledge. Future studies should focus on objective knowledge-based assessments to address this concern. Moreover, the response rate per school ranged from 16% to 65% which demonstrates that the results may not be fully representative of all final year pharmacy students in this region. Also, the findings may not be applicable to all students in the United States especially for those students who have advanced training options at their institutions.

Conclusion

In all, final year student pharmacists reported varying exposure to pharmacogenomics content in their pharmacy training; had positive attitudes towards the clinical relevance of the discipline; yet they expressed low confidence in their readiness to utilize this information in practice. Hence, practice-based training opportunities taught by well-trained faculty may be needed to prepare our future pharmacists in this discipline.

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Conflict of Interests:

All authors have no conflicts to disclose.

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Key Points

1. Final year student pharmacists had positive attitudes and perceptions towards pharmacogenomics and its clinical relevance even though majority was not ready to implement related concepts in practice.
2. Student pharmacists were more likely to feel confident in their ability to use pharmacogenomics in practice after enrolling in pharmacogenomics APPE rotations.
3. Schools of pharmacy should invest in practice-based training opportunities taught by well-trained faculty to increase readiness to implement related concepts in practice.

Tables and Figures

Table 1: Demographics Information for the Final Year Pharmacy Student Respondents.

P4 Students (n = 339)	N (%)
Gender	
Female	213 (62.8)
Male	123 (36.3)
Prefer not to disclose	3 (0.90)
Age Range	
Less than 21 years	1 (0.30)
21 - 25 years	194 (57.2)
26 - 30 years	106 (31.3)
31 - 40 years	33 (9.70)
over 40 years	4 (1.20)
no response	1 (0.30)
Highest level of education before pharmacy School	
High School Diploma	147 (43.4)
Bachelor's degree	127 (37.5)
Master's degree	11 (3.20)
Doctorate / JD	31 (9.10)
Other	22 (6.50)
No response	1 (0.30)
Post Graduate Plans	
Residency	83 (24.5)
Fellowship	19 (5.60)
Community	158 (46.6)
Hospital	32 (9.40)
Undecided	47 (13.9)

Table 2: Description of Participating Schools of Pharmacy and their Pharmacogenomics Educational Opportunities.

School/College of Pharmacy		School A	School B	School C	School D	School E	School F	School G	School H
Survey Response Rate:		**64.60%**	53.10%	**11.70%**	26.90%	27.20%	57%	16.20%	39.40%
PGx Faculty	Terminal Degree	PhD	PhD	PhD and clinical PharmD	Clinical PharmD	PhD	RPh and PhD	PhD	PhD
	Formal PGx Training	NO	NO	NO	NO	NO	YES	YES	NO
	Other PGx-related Training?	PGx coursework as part of a Pharmacology Ph.D.	Applied PGx research as an industry senior scientist position	PGx certificate program	NO	Molecular and epigenetics	PGx Post-Doc Fellowship	PGx PhD and Post-Doc Fellowship in PGx	involved in PGx research in the past
PGx Didactic Course Details	standalone or integrated?	Stand-alone	Stand-alone	BOTH	Integrated	Integrated	Stand-alone	BOTH	Stand-alone
	If integrated, what course?	N/A	N/A	Pharmacokinetics (2 lectures)	Pharmacotherapy	Pharmacology	N/A	Several courses	N/A
	If standalone, is it required or an elective?	Elective	Required	Elective	N/A	N/A	Required	Required	Required
	Average student per year for the elective courses	35	N/A	10 to 15	N/A	N/A	N/A	N/A	N/A
	When is the course offered?	1st, 2nd, or 3rd professional year	2nd professional year	3rd professional year	2nd or 3rd professional year	2nd professional year	3rd professional year	3rd professional year	2nd professional year
	Length of course/credits	one semeste; 2 credit hours	one semester; 2 credit hours	one semester; 2 credit hours	N/A	N/A	one semester; 2 credits	one semester; 2 credits	one semester; 2 credits
PGx Course ** Learning Objectives	To identify medications that require or are recommended by the FDA to have PGx testing.	YES	YES	YES	**N/A**	YES	**N/A**	YES	YES
	To recommend appropriate PGx tests for the medications that require testing.	YES	YES	YES	**N/A**	**NO**	**NO**	YES	**NO**
	To accurately interpret pharmacogenomics tests.	YES	YES	YES	**N/A**	**NO**	**NO**	YES	**NO**
	To recommend alternative therapies or doses when required by a PGx test result.	YES	YES	YES	**N/A**	YES	YES	YES	YES
	Become familiar with how to access, interpret and utilize the CPIC guidelines.	YES	**NO**	YES	**N/A**	**NO**	**N/A**	YES	**NO**
PGx APPE**	PGx APPE Opportunity	NO	YES	NO	YES	YES	NO	NO	NO
	Length of APPE	N/A	5 weeks	N/A	5 weeks	6 weeks	N/A	N/A	N/A

** The PGx APPE training addresses all the learning objectives listed.

Table 3: Survey responses from the final year pharmacy students

		Number of Respondents (%)			
	Survey Questions	**Strongly Agree / Agree**	**Neutral**	**Strongly Disagree / Disagree**	**No response**
Perception of the clinical relevance of PGx	Pharmacogenomics is an integral part of the pharmacy profession.	214 (63.1)	67 (19.8)	28 (8.26)	30 (8.85)
	Pharmacogenomics may be an integral part of my practice as a pharmacist.	205 (60.5)	62 (18.3)	42 (12.4)	30 (8.85)
	I may encounter pharmacogenomics related questions during my practice as a pharmacist.	234 (69.0)	45 (13.3)	29 (8.55)	31 (9.14)
	Pharmacogenomics is a useful tool that pharmacists and medical professionals can use to optimize medication efficacy and/or prevent adverse events.	273 (80.5)	27 (7.96)	9 (2.65)	30 (8.85)
Attitudes towards PGx education	Pharmacogenomics has been a relevant part of my doctor of pharmacy curriculum.	136 (40.1)	88 (26.0)	96 (28.3)	19 (5.60)
	Pharmacogenomics should be covered in detail for all colleges and schools of pharmacy.	239 (70.5)	67 (19.8)	13 (3.83)	20 (6.00)
	Final year (P4) pharmacy students should be required to have substantial knowledge of pharmacogenomics prior to graduation.	175 (51.6)	97 (28.6)	48 (14.2)	19 (5.60)
	Post-graduation, I intend to read up on pharmacogenomics especially on how it influences my practice and /or specialty.	188 (55.5)	81 (23.9)	51 (15.0)	19 (5.60)
Readiness to use PGx knowledge in practice	I know at least ten medications that require or are recommended to have pharmacogenomics testing as per the FDA.	108 (31.9)	55 (16.2)	150 (44.2)	26 (7.67)
	I am able to recommend the appropriate pharmacogenomics test/s for the medications that require it.	72 (21.2)	79 (23.3)	161 (47.5)	27 (7.96)
	I am able to accurately interpret pharmacogenomics tests.	91 (26.8)	75 (22.1)	147 (43.4)	26 (7.67)
	Based on the results of a pharmacogenomics test, I am able to recommend alternative therapies or dose changes when required.	107 (31.6)	82 (24.2)	124 (36.6)	26 (7.67)
	I am aware of the Clinical Pharmacogenetics Implementation Consortium's (CPIC) guidelines on how to use genetic information to guide drug therapy selection/dosing.	55 (16.2)	48 (14.2)	209 (61.7)	27 (7.96)

Figure 1: The extent of pharmacogenomics education achieved by the final year student pharmacists at the time of this survey.

Figure 1 Legend: *Percentages were calculated from the "previous exposure to pharmacogenomics demographic question". Those who did not answer were excluded from the ordered categorical variable constructed from these responses. Due to the low number of respondents who endorsed having genetics major or minor previously (2), that category was also excluded".*

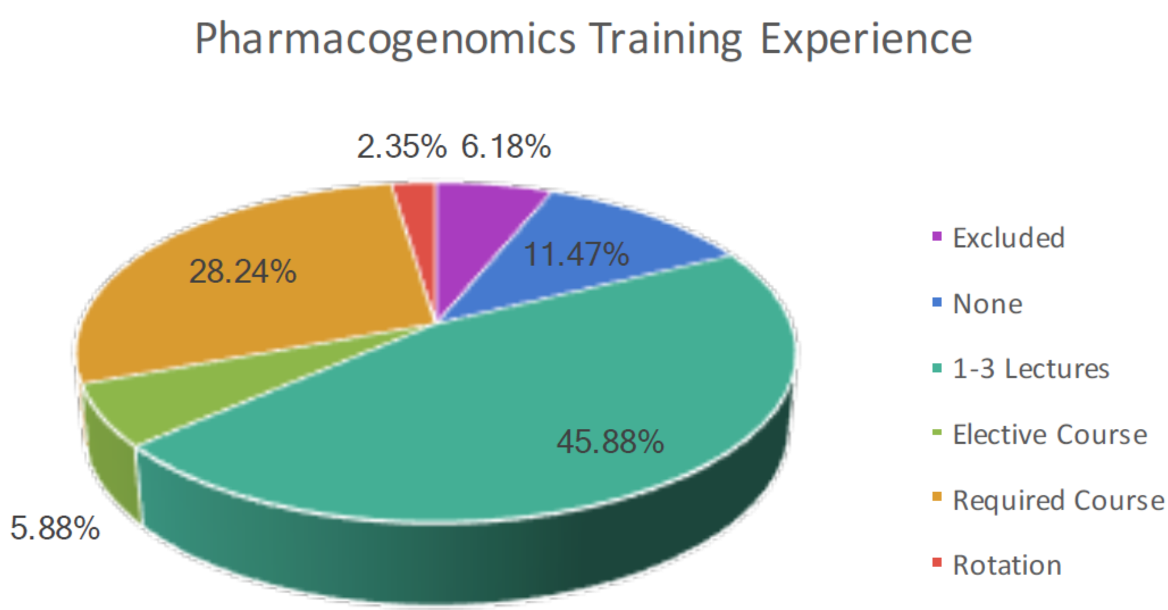

Figure 2: Relationship between exposure to pharmacogenomics education and final year student pharmacists' attitudes towards pharmacogenomics education.

Figure 2 Legend: *The effects of exposure to previous pharmacogenomics education on attitudes towards pharmacogenomics education are displayed as ß values, with 95% confidence intervals displayed as error bars. The measure of pharmacogenomics training was significantly associated with more agreement to three of the four questions assessing attitudes towards pharmacogenomics education: pharmacogenomics had been a relevant part of their curriculum (Standardized Beta (ß) =0.365, 95% Confidence Interval (CI): 0.252 - 0.477); final year pharmacy students should be required to have substantial pharmacogenomics knowledge (ß =0.150, 95% CI: 0.0.039 - 0.260); and I intend to read up on pharmacogenomics after graduating (ß =0.116, 95% CI: 0.003 - 0.229). It was also suggestively associated with the fourth question, on agreement that it should be covered in detail in all pharmacy schools (ß =0.129, 95% CI: -0.005 - 0.262).*

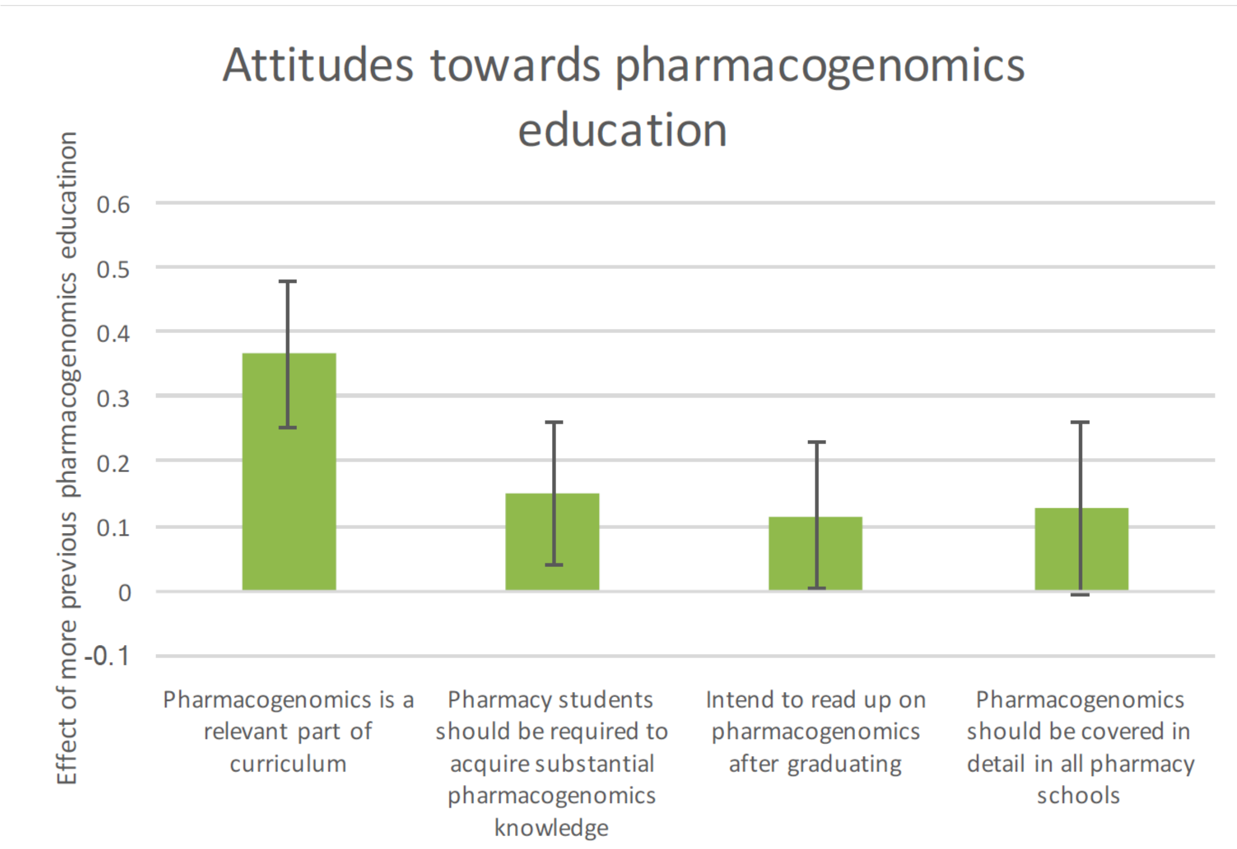

Figure 3: The relationship between exposure to pharmacogenomics education and readiness to use it in practice.

Figure 3 Legend: *Different levels of exposure to pharmacogenomics education are categorized along the x-axis, and a mean score of PGx readiness by group is displayed on the y-axis, with error bars corresponding to the standard errors within each group. The score was calculated for each person by treating agreement with each of the five readiness statements as 1, and disagreement as -1 (neutral is treated as 0) and summing all five together. The correlation between level of pharmacogenomics education exposure and readiness score was 0.389 (95% Confidence Interval: 0.291 - 0.478; R2 = 0.151), suggesting a positive relationship between more exposure to pharmacogenomics education and increased readiness to use pharmacogenomics in practice.*