Pharmacogenomics Based Practice in Malaysia: The Attitude, Knowledge and Adoption by the Healthcare Professionals

Bannur Z[a], Bahaman S[a], Salleh MZ[a,b], Teh LK[a,b]

[a]*Integrative Pharmacogenomics Institute, Universiti Teknologi MARA, Puncak Alam Campus, 42300 Bandar Puncak Alam, Selangor, Malaysia.*
[b]*Faculty of Pharmacy, Universiti Teknologi MARA, Puncak Alam Campus, 42300 Bandar Puncak Alam, Selangor, Malaysia*

ABSTRACT

Introduction: Knowledge, attitude as well as adoption of pharmacogenomics in clinical practice among the pharmacists and physicians in Malaysia have not been reported. This cross-sectional study explores various facets of the two professions as related to pharmacogenomics to determine the need and preferred method to improve education among them. This study also aims to identify the current state of pharmacogenomics practice in Malaysia to help identify barrier and solution to reap advantages from pharmacogenomics practices. **Methods**: A questionnaire consisting of 38 questions in five parts was adopted and validated. It explores the respondents' characteristics, attitude, knowledge, adoption and education. It was distributed online to 1500 pharmacists and physicians over five months. **Results:** Pharmacists differed from the physicians in terms of attitude, knowledge, adoption and education. Overall, adoption rate of pharmacogenomics was found to be low but its anticipation for future adoption is high, and benefits were reported by healthcare professionals who have used the test in a clinical setting. Majority of respondents had poor to fair knowledge and nearly half have had no prior formal teaching on pharmacogenomics. Interest in the education is very high, and most of them preferred to learn pharmacogenomics via continuous professional education programs. **Conclusion**: Pharmacogenomics is a field that promises many benefits, but to reap these benefits require its implementation in clinical setting. Pharmacists and physicians need to be equipped with adequate knowledge and positive attitude towards pharmacogenomics.

KEYWORDS: Pharmacogenomics, education, attitude, health practitioners

INTRODUCTION

Pharmacogenomics based clinical practice have been successfully adopted by many developed countries in order to enhance personalised medicine and provide quality health care. The effort in realising personalised medicine is further expedited with the advance of sequencing technologies and the completion of human genome projects, including the Malay genome that was published recently.[1] A relevant example of the impact of pharmacogenomics is the genetic polymorphism of HLA-B*1502 which has been shown to reduce adverse drug reactions by genotyping of patients for HLA-B*1502 before carbamazepine is prescribed to patients at risk of Steven Johnson syndrome and Toxic Epidermal Necrolysis.[2] The impact of pharmacogenomics in optimum health care is further strengthened by Food and Drug Administration (FDA) announcing labelling changes to warfarin, clopidogrel, trastuzumab, cetuximab, maraviroc, abacavir, mercaptopurine, carbamazepine, and irinotecan and dasatinib and many more drugs to include the potential usefulness of genetic testing.[3-6]

Inclusion of pharmacogenomics in the academic curricula is important as the knowledge and training for the health care providers are vital to ensure professional practice of pharmacogenomics in clinical settings.[7,8] In one study, the second most cited barrier (57%) to adopting pharmacogenomics practice is the limited providers' knowledge and awareness.[9] As the drug experts in the healthcare system, pharmacists have important roles to educate patients via counselling; and to assist health providers in interpreting literature and test results related to pharmacogenomics in order to make the best clinical decisions.[10,11] One practical application which they must develop is the skill to translate patient's genetic history for optimum drug therapy.[12] Ultimately, health care providers hold most of the liability as they decide to prescribe a drug with or without ordering

Corresponding author:

Prof Dr Teh Lay Kek
Fellow Researcher
Integrative Pharmacogenomics Institute,
Universiti Teknologi MARA
42300 Puncak Alam
Malaysia
Tel:+603 32584652
Fax: +603 32584658
e-mail: tehlaykek@gmail.com/ tehlaykek@puncakalam.uitm.edu.my

pharmacogenomics tests based on their professional assessment of risk and benefit.

MATERIALS AND METHODS

A draft of the survey questions was developed based on literature review. The draft questionnaire was then reviewed by researchers at Integrative Pharmacogenomics Institute, (iPROMISE) at Universiti Teknologi MARA and their feedback was incorporated to make the second draft. A pilot study was then conducted on 10 pharmacists and physicians in exactly the same way as it was then administered in the main study. Ambiguous questions were identified so that the questions could be reworded, and the meaning clarified. Instructions that are difficult to understand were also revised, and questions deemed unnecessary were discarded. The revised self-administered survey written in English was distributed via email. The respondents submitted their responses online and were contacted with up to three reminders to encourage participation and minimize non-response rates. The answers for each question applicable to them were made compulsory, so no incomplete responses were received.

The questionnaire was distributed to 1500 pharmacists and physicians working in Malaysia. Once the questionnaires were completed, the demographics of the sample population were compared to the actual population to demonstrate how well the responses can represent the desired population of healthcare professionals.

The questionnaire consists of 38 questions and divided into four parts;

Part 1: Respondent characteristics

Information on respondents' age, gender, ethnicity, profession, position, specialization, number of years practicing, practice setting, location of pharmacy or medical school attended, and primary employers were obtained.

Part 2: Attitude

The respondents' opinion on financial coverage on pharmacogenomics testing and their concerns over the confidentiality and discrimination issues as well as attitudes were assessed. Eight questions were asked on a 5-point Likert scale of not likely, not concerned or not comfortable to very likely, very concerned or very comfortable. The mean value and standard deviations were obtained, and the total positive score was computed. The internal consistency of the attitude scale was tested and found to be acceptable (α= 0.715).

Part 3: Knowledge

Understanding on pharmacogenomics and five factual questions on knowledge were surveyed. Their knowledge on pharmacogenomics shed lights on the possible needs for further education.

Part 4: Adoption

The respondents' practice with respect to pharmacogenomics, the benefits they have obtained, as well as the level of evidence they require to consider ordering or recommending pharmacogenomics test and their information source were reviewed.

Part 5: Education

Finally, prior education, desire and interest in pharmacogenomics education were obtained.

Data analysis

The data collected were analyzed using the Statistical Package of Social Sciences (SPSS) program version 18.0. The methods used to analyze the data include an analysis of descriptive statistic variables such as frequency and percentages for the categorical variables. The Pearson Chi-Square test was done to determine the differences. The continuous variables were expressed by means and standard deviations and analyzed using the independent samples T-test and one-way ANOVA. When F statistic was significant, Tukey post hoc test was used. The chosen level of significance is $p < 0.05$.

RESULTS

Demographics of Respondents

A total of 503 (33.5%) responses were received, and all the responses were found to be complete. The respondents' characteristics are shown in Table I. The majority of respondents were pharmacists (324, 64.4%) and the rest were physicians (179, 35.6%). Most of the respondents were females (55.7%). The mean age of all was 32.06 ± 7.06 years old. Pharmacists were younger (29.87±6.35) compared to the physician counterparts [35.41±6.23 $p < .001$]; and the physicians were in practice longer than pharmacists (10.38 ± 6.7 years vs 6.62 ± 6.21years; $p < 0.001$).

Most respondents were Malays (66.2%), followed by Indians (17.7%), Chinese (14.3%) and other Bumiputras (1.8%). Majority of these health professional practice in suburban areas (64.2%), and the rest practice in rural (21.1%) and urban (14.7%) areas ($x^2 = 7.484$, $p= 0.024$). Seventy percent of the pharmacists who participated in this study, studied in local public universities (69.1%) while majority of physicians studied in local private universities ($x^2 = 58.724$, $p < 0.001$). Eighty percent (82.7%) of the pharmacists work in government hospitals and only eight percent in private hospitals. In contrast, 55.9% of physicians are employed in government hospitals vs private hospitals (12.8%; $x^2 = 80.656$, $p < 0.001$).

Table I. Demographics of respondents

Personal characteristics	Pharmacist (N=324)		Physician (N=179)		Total (N=503)		P value
	N	*%*	*N*	*%*	*N*	*%*	
Gender							
Male	136	42.0	87	48.6%	223	44.3%	x^2 = 2.052,
Female	188	58.0	92	51.4%	280	55.7%	p = .152
Age Group							
<25	92	28.4	37	20.7%	92	18.3%	
26-30	120	37.0	54	30.2%	157	31.2%	x^2 = 117.185,
31-35	53	16.4	49	27.4%	107	21.3%	p < .001*
36-40	38	11.7	25	14.0%	87	17.3%	
41-45	12	3.7	12	6.7%	37	7.4%	
46-50	3	.9	2	1.1%	15	3.0%	
>50	6	1.9	2	1.6	8	1.6%	
Ethnicity							
Malay	277	85.5	56	31.3%	333	66.2%	
Other Bumiputra	1	.3	8	4.5%	9	1.8%	x^2 = 160.351,
Chinese	29	9.0	43	24.0%	72	14.3%	p < .001*
Indian	17	5.2	72	40.2%	89	17.7%	
Years of Practice							
0-4	168	51.9	26	14.5%	194	38.6%	
5-9	78	24.1	50	27.9%	128	25.4%	x^2 = 78.786,
10-19	66	20.4	84	46.9%	150	29.8%	p < .001
20-29	10	3.1	17	9.5%	27	5.4%	
>29	2	.6	2	1.1%	4	.8%	
Practice Setting							
Rural	75	23.1	31	17.3%	106	21.1%	
Suburban	211	65.1	112	62.6%	323	64.2%	x^2 = 7.484,
Urban	38	11.7	36	20.1%	74	14.7%	p = .024*
Location of school							
Public university in Malaysia	224	69.1	73	40.8%	297	59.0%	
Private university in Malaysia	34	10.5	68	38.0%	102	20.3%	x^2 = 58.724,
Other countries	66	20.4	38	21.2%	104	20.7%	p < .001*
Primary Employer							
Government hospital	268	82.7	100	55.9%	368	73.2%	
Private hospital	26	8.0	23	12.8%	49	9.7%	x^2 = 80.656,
Pharmacy or medical school/ university	10	3.1	33	18.4%	43	8.5%	p < .001
Private practice/ self-employed	5	1.5	23	12.8%	28	5.6%	
Community pharmacy	12	3.7	0	.0%	12	2.4%	
Regulatory pharmacy	3	.9	0	.0%	3	.6%	

*. The Chi-square statistic is significant at the 0.05 level.

Attitude and knowledge of respondents on pharmacogenomics testing

Most respondents believe that full coverage for the tests should always be given. Opinions differ significantly across gender, profession, years of practice, ethnicity, practice setting and primary employer ($p < 0.05$). Females (58.4%) are more inclined for full coverage compared to males (41.6%; $p < 0.001$), as are pharmacists compared to physicians (67.0% vs. 33.0%; $p < .001$).

Most of those who studied in local public universities (60.1%) believe full coverage should be given, while only 20.7% graduates of local private universities and 19.2% graduates of foreign countries believe it should be given always or sometimes or not necessary ($p <0.001$). Government hospital employees are in favour of full coverage with most responding always (52.2%) and sometimes (42.7%); only very few responded never (5.2%; $p < .001$). In contrast, a quarter of private hospital employees responded never. Majority of those employed by universities responded sometimes (83.7%). Healthcare professionals who have ordered or recommended pharmacogenomics testing in the past are more likely to feel that full coverage should be provided ($p = 0.039$).

With reference to Table II, attitude scores varied according to location of studies; respondents graduated from public universities in Malaysia scored higher for positive attitude than private universities in Malaysia ($p = .024$), but the difference in attitudes between graduates of local private and foreign countries was not significant. Pharmacists tend to score better attitude compared to physicians ($p < .001$). Among the physicians, specialists and medical officers scored higher than consultants ($p = 0.004$), but there was no significant difference between specialists and medical officers. Having ordered a pharmacogenomics test did not affect their attitude ($p = 0.709$). Attitudes did not vary significantly according to their understanding of pharmacogenomics either ($p = .177$).

There are significant differences in the scores for the questions on pharmacogenomics knowledge except for the last when we compared the scores between the professions. More pharmacists believe in the effect of a person's genetics on their response to medications, and similarly, the variance in genetics accounting for 95% of variance in drug disposition and effects (Table II; $p < .001$). However, physicians are more aware of warfarin's package insert warning relating to pharmacogenomics ($p < .001$). The question on whether genetic determinants of drug's response change over a person's lifetime had the least correct answers, with more than half of pharmacists and physicians answering true. Regardless, pharmacists scored higher for correct answer ($p = 0.005$).

Attitude scores also varied according to location of their studies; public universities in Malaysia scored higher than private universities in Malaysia (Table III; $p = 0.024$), but difference between attitudes of graduates of local private and foreign countries was not significant.

At the current state, knowledge did not differ significantly across gender (Table III; $p = 0.463$) and previous use of pharmacogenomics testing ($p = 0.959$). Respondents younger than 26 years old have better knowledge than the other age groups (Table III; $p < 0.001$). Similarly, there was a significant difference with practicing years. Those who have practiced for 0-4 years had significantly higher scores than those who have practiced longer (Table III; $p = .001$).

There was also a difference in terms of knowledge scores among respondenst with regards to pharmacist position and location of school attended. Those who studied in public universities in Malaysia had significantly higher scores than local private university ($p = 0.005$) and other countries ($p = 0.040$). Scores between local private university and universities in other countries did not differ significantly.

There is a statistically significant difference between self-perceived understanding and knowledge scores [$F (2, 500) = 4.291$, $p = 0.014$]. Those who rated their understanding as poor scored significantly less than those who rated themselves as having a good understanding ($p = .027$). Healthcare professionals that received some form of pharmacogenomics education scored significantly higher. Those who studied pharmacogenomics at the undergraduate level or seminars or workshops had better knowledge compared to those who didn't.

Adoption

Only 5.8% of the healthcare professionals who participated in this study have ordered or recommended pharmacogenomics testing in the past. For all of them, their patients have benefited in some way. Majority (93.1%) of patients benefited from reduced drug toxicity while nearly half of them showed improved adherence to therapy and improved their understanding of their disease or therapy.

As shown in Table IV, there was a significant difference with regards to pharmacist position, and whether or not they have ordered or recommended the test; 33% were of U54 grade ($p < 0.05$). Physicians also showed significant difference, with half of those that have ordered or recommended testing being medical officers and the other half specialists ($p = 0.01$). Cardiologists also felt better informed about the availability and application of genetic testing ($p = 0.016$) than other specialists. Healthcare professionals who studied abroad were also more likely to order the test than those that studied in local public or private universities (10.4 vs. 4.9 and 1.2%; $p = .019$). More orders were made by the private hospital than government hospitals (14.6 vs. 3.5%; $p = .28$).

Table II. Attitude and knowledge of respondents on pharmacogenomics

Attitude	Pharmacist		Physician		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
1 In your opinion, how likely is it that pharmacogenomic testing will help to decrease the number of adverse drug reactions?	3.84	.83	4.26	.58	3.99	.78
2 In your opinion, how likely is it that pharmacogenomic testing will help to decrease the cost of developing new drugs?	2.35	1.09	2.49	1.48	2.40	1.24
3 In your opinion, how likely is it that pharmacogenomic testing will help to decrease the time it takes to find the optimal dose for warfarin patients?	3.13	.85	3.17	.95	3.15	.88
4 In your opinion, how likely is it that pharmacogenomic testing will help to decrease the number of adverse reactions experienced by patients on warfarin?	3.95	.72	4.26	.57	4.06	.69
5 How concerned are you that unauthorized persons may gain access to the results of a patient's pharmacogenomic testing?	2.54	.95	2.46	.84	2.51	.91
6 How concerned are you that the pharmacogenomic testing may result in discrimination by employers and/or insurance companies?	2.54	.95	2.46	.84	2.51	.91
7 How comfortable would you be having genetic information incorporated into the determination of your patient's initial warfarin dose?	3.95	.72	4.26	.57	4.06	.69
8 If you were the patient being started on warfarin, how comfortable would you be having genetic information incorporated into the determination of your initial dose of warfarin?	3.95	.72	4.26	.57	4.06	.69
Knowledge (Correct responses to true or false questions assessing pharmacogenomics knowledge by profession and total knowledge score)						
9 Subtle differences in a person's genome can have a major impact on how the person responds to medications. [a] t(226) = 6.193, p < .001*	.95	.22	.73	.44	.87	.33
10 Genetic determinants of drugs response change over a person's lifetime. ▪ [a] t(394) = 2.816, p = .005*	.41	.49	.28	.45	.36	.48
11 Genetic variants can account for as much as 95% of the variability in drug disposition and effects. [a] t(331) = 5.347, p < .001*	.73	.44	.49	.50	.65	.48
12 The package insert for warfarin includes a warning about altered metabolism in individuals who have specific genetic variants. [a] t(396) = -6.045, p < .001*	.44	.50	.71	.46	.54	.50
13 Pharmacogenomic testing is currently available for most medications. ▪ [a] t(325) = 1.862, p = .064	.85	.36	.78	.42	.82	.38

▪ False statements
*. The mean difference is significant at the 0.05 level.
[a]. Levene's Test for Equality of Variances p < .05 indicates the assumption of homogeneity of variances is violated, a t-statistic not assuming homogeneity of variance was computed.

Table III. Association of the total attitude and knowledge scores with respondent characteristics

	Total Attitude Score				Total Knowledge Score			
	Mean	*SD*	*F*	*p*	*Mean*	*SD*	*F*	*p*
Age group								
<26	28.12	3.97	2.102	.052	3.62	.90	4.961	< .001*
26-30	28.29	3.88			3.36	.97		
31-35	29.45	3.90			3.10	1.02		
36-40	28.90	3.24			3.10	1.06		
41-45	28.49	2.82			2.86	1.13		
46-50	30.53	2.23			2.67	1.18		
>50	28.88	4.88			2.75	1.04		
Gender								
Male	28.67	3.79	0.013	.909 [a]	3.20	1.08	0.539	.463a
Female	28.73	3.70			3.28	.98		
Ethnicity								
Malay	28.24	3.71	6.463	< .001*	3.32	1.00	2.303	.076
Other Bumiputra	28.89	1.69			2.89	.93		
Chinese	29.03	4.00			3.06	1.01		
Indian	30.13	3.37			3.12	1.15		
Profession								
Pharmacist	28.10	3.76	0.795	.373 [a]	3.38	.96	1.464	.227a
Physician	29.79	3.44			2.99	1.10		
Pharmacist position								
U41	28.05	3.96	0.683	.637	3.53	.89	2.785	.018*
U44	28.25	3.48			3.32	.96		
U48	27.60	3.34			3.32	1.02		
U52	29.10	3.99			2.95	1.07		
U54	29.33	4.50			2.67	1.03		
Special Grade	27.50	7.78			2.50	.71		
Physician								
Medical officer	29.68	3.55	7.802	.001*	3.05	1.05	1.236	.294
Specialist	28.46	2.97			2.96	1.35		
Consultant	32.19	1.86			2.71	1.10		
Specialty								
Anaesthesiology	26.00	1.41			3.00	.00	28.00	
Paediatrics					1.00			
Psychiatry	28.50	.71			2.50	2.12		
Family/general practice, internal, preventive	29.00	.00	1.956	.126	2.50	.71	0.247	.930
Cardiology	29.73	3.28			3.20	1.37		
Oncology	26.00	1.55			3.00	1.55		
Years of practice								
0-4	28.49	3.91			3.49	.89		
5-9	28.27	3.65			3.27	1.05		
10-19	29.17	3.59	1.547	.187	3.02	1.06	6.331	< .001*
20-29	29.48	3.60			2.59	1.12		
>29	29.75	2.22			2.75	1.26		
Practice setting								
Rural	28.85	4.09			3.19	1.03		
Suburban	28.80	3.64	1.307	.272	3.21	1.03	1.082	.340
Urban	28.05	3.58			3.45	1.00		
Location of school attended								
Public university in Malaysia	3.34	0.99			3.34	.99		
Private university in Malaysia	3.07	1.14	3.595	.028*	3.07	1.14	6.383	.002*
Other countries	3.13	1			3.13	1.00		
Primary employer								
Government hospital	28.61	3.84			3.33	1.02		
Private hospital	28.61	4.22			3.04	1.09		
Pharmacy or medical school/ university	30.33	2.83			3.17	.92		
Private practice/self-employed	27.64	2.16	2.217	.051	3.24	.83	1.696	.134
Community pharmacy	28.17	3.13			2.67	.89		
Regulatory pharmacy	29.33	1.53			3.67	.58		
Ordered or recommended testing								
Yes	*28.45*	*3.65*	*0.065*	*.798 [a]*	*3.21*	*1.18*	*.003*	*.959[a]*
No	*28.72*	3.74			3.24	1.02		

*. The mean difference is significant at the 0.05 level.

[a]. F statistic and p-value for Levene's Test for Equality of Variances. p > .05 indicates the assumption of homogeneity of variances is met.

Table IV. Predictors of pharmacogenomic adoption and interest in education and preferred education mode

Responses to questions on predictors of adoption of pharmacogenomics	Pharmacist		Physician		Total
	N	*%*	*N*	*%*	*%*
Believe that patients' genetic profile influences drug therapy					
Yes					
No					
Feel adequately informed about availability of genetic testing and its application in drug therapy					
Yes					
No					
Ordered or recommended pharmacogenomic test					
Yes					
No					
Anticipate ordering or recommending pharmacogenomic test in the future					
Yes					
No					
Rely on FDA labels					
Yes					
No					

Sources of pharmacogenomic information by profession	Pharmacist		Physician		Total
	N	%	N	%	%
Drug labels	192	59.3	122	68.2	62.4
Internet	257	79.3	103	57.5	71.6
Genetic test lab	184	56.8	14	7.8	39.4
Pharmacists	200	61.7	154	86.0	70.4
Physicians	13	4.0	20	11.2	6.6

Preferred education mode	Pharmacist		Physician		Total
	N	%	N	%	%
Prior pharmacogenomic education	126	38.9	125	69.8	49.9
Undergraduate pharmacogenomic education	175	54.0	36	20.1	41.9
Postgraduate pharmacogenomic education	16	4.9	20	11.2	7.2
Continuing education	34	10.5	1	0.6	7.0
Seminar or workshop	53	16.4	24	13.4	15.3
Ward rounds	3	.9	35	19.6	7.6
Interest in pharmacogenomic education					
Yes	312	96.3	153	85.5	92.4
No	12	3.7	26	14.5	7.6
Education offerings of interest					
Ward round	5	1.5	49	27.4	10.7
Seminar or lecture	95	29.3	53	29.6	29.4
CPE	217	67.0	108	60.3	64.6
Web-based CPE 192	59.3	99	55.3	57.9	
Half-day conference	102	31.5	58	32.4	31.8
All-day conference	85	26.2	47	26.3	26.2

*. The Chi-square statistic is significant at the 0.05 level
Note. Respondents were allowed to choose more than one answer.
CPE: Continuing professional education

As a whole, even though only a small minority has ordered or recommended the tests, 41.4% feel that they will do so in the future. Specialists had a much higher anticipation of ordering the test in the future than other physicians (71.4 vs. 37.9 and 28.6%; p=.036).

Overall, the majority of respondents (64.2%) rely on FDA labels. Further, out of those that have ordered the tests, 69.0% relied on the labelling ($p < 0.001$). The most frequently quoted sources of information were the internet (71.6%), pharmacists (70.4%), and drug labels (62.4%), followed by genetic test laboratory (39.4%) and physicians (6.6%). More pharmacists than physicians rely on the internet for pharmacogenomics information while fewer graduates of private local universities use it as a source compared to local public and foreign universities ($p<0.001$ for both). Significantly, more pharmacists rely on laboratories to perform genetic test and account for 92.9% of those who use results obtained from the genetic test as information source ($p<0.001$).

Education

Referring to Table IV, more physicians lacked pharmacogenomics education when compared to pharmacists ($x^2=44.160$, $p<.001$). More pharmacists received pharmacogenomics education at the undergraduate level than physicians ($x^2=54.415$, $p<.001$) while at the postgraduate level, more physicians studied pharmacogenomics ($x^2=6.745$, $p=.009$). Pharmacists also had more pharmacogenomics education via continuing professional education programs ($x^2 = 17.579$, $p < 0.001$) while more physicians learned about pharmacogenomics via ward rounds ($x^2 = 57.283$, $p < 0.001$).

Lack of pharmacogenomics education is more prevalent in males compared to females ($x^2 = 7.965$, $p = 0.005$). Meanwhile, significantly more graduates of public local universities (63.6%) received some form of pharmacogenomics education compared to other graduates ($x^2 = 65.895$, $p < 0.001$). There was also a significant difference when compared against their primary employer ($x^2 = 45.029$, $p < .001$). In addition, most of those who have previously ordered or recommended the test have studied pharmacogenomics before (72.4%; $x^2 = 6.239$, $p = .012$).

There are more female undergraduates who were exposed to pharmacogenomics than males ($x^2 = 6.069$, $p=.014$). Higher undergraduate pharmacogenomics education were also found in 21-25 year olds, U41 pharmacists, those studying in local public universities, those working in government hospitals, and those having practiced for 4 years or less ($p < .001$ for all). Those involved in the continuing education programs on pharmacogenomics are mostly U41 pharmacists with 19.7% ($x^2 = 28.443$, $p < .029$), graduates of local public universities (9.1%; $x^2 = 7.865$, $p = .020$), and those with 0-4 practicing years (16.5%; $x^2 = 124.758$, $p < .001$). More practitioners in rural areas (12.3%) had postgraduate pharmacogenomics studies compared to those practised in urban (9.5%) and suburban (5.0%; $x^2 = 7.111$, $p = .029$).

Pharmacists are more interested in pharmacogenomics education than physicians ($x^2 = 19.333$, $p < .001$). The most preferred method of education is continuing professional education and web-based continuing professional education followed by half-day conference, seminar or lecture, all-day conference, and ward round. Majority of the physicians showed interest in ward round education (Table IV).

DISCUSSIONS

Nearly half of the respondents believe that full financial coverage should always be given for pharmacogenomics testing. A previous study has demonstrated that insufficient coverage is one of the main cause for non-adoption.[13] This economic barrier brings forth the issue of the payers' needs; among them are studies that demonstrate the impact of pharmacogenomics testing on clinical and economic outcomes, studies comparing the testing to usual care and those conducted in real-world populations.[14]

Studies interviewing researchers have identified a fear of insurance and racial discrimination.[15,16] Similarly, 38.7% of the respondents were concerned about the discrimination by employers and insurance companies due to their genetic profile. Females had a significantly higher concern for discrimination ($p = 0.031$), in accordance with the findings in another study that revealed females were generally more afraid of the perceived risks.[17]

In this study, lower percentage of the respondents (15.7%) believed that unauthorized persons may gain access to the pharmacogenetics test results and therefore, had less fear of privacy intrusion; compared to other studies of which the healthcare professionals, researchers and leaders of drug companies and regulatory agencies had more concerns on privacy intrusion (40%).[18]

Additionally, the review by Dodson[18] also identified nine articles addressing the perceived benefits. In this study, 78.5% of respondents felt that adverse drug reaction would be decreased, while 81.5% felt that adverse drug reaction for warfarin would be reduced. These figures are much higher than the 46% reported to perceive this benefit in another study of healthcare professionals, and the 42% of anticoagulation providers that were undecided on the matter.[18] Only a minority of the healthcare professionals in this study felt that it would save time (23%) and cost (14.1%). Their perception of the cost may be a concern because although pharmacogenomics is expected to be more cost-effective in the long run owing to reduced incidence of adverse drug reactions. However, it will directly cost more than existing options and requires initial financial investment.

Overall, pharmacists have more positive attitude towards pharmacogenomics testing compared to physicians. In the study from which the questions on attitudes were adopted, positive attitude increased with self-reported knowledge.[19] However, in this study, there was no significant association found. Previous use of pharmacogenomics testing did not improve attitude either. Instead, differences in attitude were identified among the participants when compared across ethnicity and location of studies. Malays and graduates of local public universities have the most positive attitude.

Majority (95.5%) of healthcare professionals rated their own knowledge of pharmacogenomics as poor to fair compared to 83% in a study set in USA. This means that a very small percentage (4.5%) felt that they have good to excellent knowledge, 90% of whom were pharmacists vs. 10% physicians. The respondents seem to assess their own understanding fairly when perceived, and actual knowledge were compared - a rating of good understanding scores higher than poor. When their actual knowledge was tested, pharmacists also scored higher overall. However, a common misconception was identified, which requires correction: most respondents believe that genetic determinants of drug response change over a person's lifetime.

Those 30 years old or younger and those practicing for four years or less scored the highest in knowledge, most likely because of how relatively new the field of pharmacogenomics is and how recent its introduction into medical and pharmacy school's curricula, giving the added advantage to those who graduated more recently. Like attitude, location of studies affected knowledge, with graduates of local public universities scoring higher.

Other factors that are associated with a better knowledge of pharmacogenomics include prior education exposure, significantly so at the undergraduate levels or seminars or workshops. Nearly half (47.2%) of the respondents had no prior pharmacogenomics education, with physicians being even less exposed compared to pharmacists. Application of pharmacogenomics is more prevalent in those who have studied pharmacogenomics, which stresses the importance of the healthcare professionals' education.

Fortunately, the interest in pharmacogenomics education is very high (94.2%), especially among the pharmacists. The most preferred education that they wish to receive is continuous professional education, and more than half was interested in web-based continuous professional education. Hence, appropriate continuous professional education programs should be carefully developed and made available to all of them to better prepare the healthcare professionals to play their part. In particular, they should be properly informed about the availability of the tests.

Use of testing among respondents is very low, at only 5.8% compared to 12.9% in another study by Stanek et al.[13] On the other hand; a higher number of respondents anticipated the use in the next six months (41.4% vs. 26.4%). A promising finding is that all of them have benefited from the testing in some way, with up to 93.1% claimed reduced drug toxicity. Interestingly, far more healthcare professionals in Malaysia felt their patients' adherence to therapy was improved (48.3% vs. 4.1%).

Graduates of foreign universities were more likely to order or recommend tests, as were the employees of private hospitals. Not surprisingly, specialists were found to have higher use of pharmacogenomics than the other physicians, considering the drugs and diseases that involved pharmacogenomics testing.

In obtaining information about pharmacogenomics, seventy percent respondents rely on the Internet and pharmacists, followed closely by drug labels. The least frequently used information source is physicians (6.6%). Less than half rely on laboratory, which performs genetic test, and physicians refer to pharmacists more than pharmacists do to their colleagues. This huge gap between the two professions shows that the responsibility for answering questions on pharmacogenomics heavily lies on pharmacists. Similar to respondents' preference towards web-based continuing professional education programmes, they currently depend on the Internet as a major source. This interest highlights a demand for a reliable information outlet on the Internet so that they can easily educate themselves with. FDA approval or recommendation seems to matter the least, and there is a strong demand for pharmacist or physician specialty guideline pertaining to pharmacogenomics. Currently, there is a lack of guidelines on pharmacogenomics practises.

CONCLUSION

The results obtained from this study are useful in determining the need in improving education in pharmacy and medical schools and continuing education programs and the preferred education method. It may also help to identify misconceptions that require rectification. Pharmacists differed from physicians in terms of attitude, knowledge, adoption and education. Most expect full financial coverage to always be given for the tests. Overall, adoption rate was found to be low and a higher adoption rate is associated with better knowledge and prior education exposure, and the actual benefits seen is high. Anticipated use in the future is also high. Pharmacists are a major source of information compared to physicians. Majority of respondents had poor to fair knowledge and nearly half have had no pharmacogenomics education. Interest in the education is very high, and most of them expressed interest in learning via continuous professional education programs.

Acknowledgements

The authors wish to thank all the participants for this study.

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