Received: 24 July 2024 | Revised: 6 October 2024 | Accepted: 14 October 2024

DOI: 10.1111/cts.70057

ARTICLE

The needs and gaps in pharmacogenomics knowledge and education among healthcare professionals in Malaysia: A multisite Delphi study

Safa Omran[1] | **Siew Lian Leong**[1] | **Ali Blebil**[1] | **Devi Mohan**[2] | **Wei Chern Ang**[3,4] | **Siew Li Teoh**[1]

[1]School of Pharmacy, Monash University Malaysia, Subang Jaya, Selangor, Malaysia

[2]Jeffrey Cheah School of Medicine and Health Sciences, Monash University Malaysia, Subang Jaya, Selangor, Malaysia

[3]Clinical Research Centre, Hospital Tuanku Fauziah, Ministry of Health Malaysia, Kangar, Malaysia

[4]Department of Pharmacy, Hospital Tuanku Fauziah, Ministry of Health Malaysia, Kangar, Malaysia

Correspondence
Siew Li Teoh, School of Pharmacy, Monash University Malaysia, Jalan Lagoon Selatan, Bandar Sunway, 47500 Subang Jaya, Selangor, Malaysia.
Email: teoh.siew.li@monash.edu

Abstract

Lack of pharmacogenomics knowledge among healthcare professionals is the most significant cited barrier to implementing pharmacogenomics in clinical settings. Despite the growth in research initiatives and awareness of pharmacogenomics, healthcare professionals continue to report a lack of knowledge and confidence in practicing pharmacogenomics. This study aims to assess the current pharmacogenomics knowledge gaps and learning needs of healthcare professionals in Malaysia. A modified Delphi with a multidisciplinary expert panel was conducted, and a purposive sampling method was used with predefined selection criteria. Fourteen study sites in Malaysia were included. The cut-off value to approach consensus was predefined as a threshold of 60% or higher, and a quantitative descriptive statistical analysis was performed. The study demonstrated that all experts rated the suggested educational content components as essential/important to be included in the educational intervention. Additionally, experts highlighted the significant barriers and gaps to adopting and practicing pharmacogenomics. To conclude, this multisite Delphi study enabled the development of a tailored, effective, evidence-based, competency-based educational intervention in pharmacogenomics for healthcare professionals in Malaysia. To keep up with the rapid evolution of the pharmacogenomics field, healthcare professionals should be equipped with the necessary competencies required to practice pharmacogenomics for better health outcomes. Future research is needed to determine the feasibility of the proposed educational intervention.

Study Highlights

WHAT IS THE CURRENT KNOWLEDGE ON THE TOPIC?

Lack of PGx knowledge among HCPs is the most significant cited barrier to implementing PGx in clinical settings. Despite the growth in research initiatives and

awareness of PGx, HCPs continue to report a lack of knowledge and confidence in practicing PGx.

WHAT QUESTION DID THIS STUDY ADDRESS?

The study aimed to identify the gaps in PGx knowledge and the specific learning needs of HCPs in Malaysia. This study provides a foundation for developing targeted educational programs to enhance the competencies of HCPs in this field. This study aims to answer the following questions: What are the PGx competency levels among HCPs in Malaysia, and what educational interventions can effectively enhance their PGx practice?

WHAT DOES THIS STUDY ADD TO OUR KNOWLEDGE?

The study provides a comprehensive assessment of the current state of knowledge and the educational needs of HCPs in Malaysia regarding PGx. It emphasizes the specific areas where knowledge is lacking and identifies the key topics that need to be addressed in training programs. This information is essential for developing effective educational interventions that can improve the PGx practice in clinical settings.

HOW MIGHT THIS CHANGE CLINICAL PHARMACOLOGY OR TRANSLATIONAL SCIENCE?

The study findings can guide the development of tailored educational interventions to address the identified gaps in PGx knowledge. Providing PGx education will improve healthcare professionals' knowledge and competency in integrating PGx into clinical decision-making. Consequently, it will improve health outcomes and substantially reduce overall healthcare expenses. Within the context of translational science, the study emphasizes the significance of education in bridging the gap between scientific discoveries and their practical implementation in healthcare.

INTRODUCTION

Precision pharmacotherapy was founded based on the concept that "one drug does not fit all." It involves using therapeutic drug monitoring, evaluating liver and kidney functions, genetics, environmental and lifestyle exposures, and looking at other unique aspects of the patient or illness to guide drug selection and administration. Hence, genetic data can be employed to optimize medication selection, efficacy, and safety. As a result, pharmacogenomics (PGx) was developed and is now widely regarded as a vital component of precision pharmacotherapy.[1] Evidence shows that utilizing PGx test results can avoid 20%–30% of adverse drug events (ADEs) and substantially decrease healthcare expenses and mortality linked to ADEs.[2,3]

Southeast Asian countries, including Malaysia, are multi-ethnic; ethnic diversity, therefore, reflects genetic and pharmacological response variability.[4] The Southeast Asian Pharmacogenomics Research Network (SEAPharm) was established in 2012 in Asia with the aim of promoting and enhancing PGx implementation and research across diverse groups in this region. According to the SEAPharm member countries, one of the major barriers and limitations to the implementation of PGx is the lack of PGx education and knowledge among stakeholders, particularly healthcare professionals.[5] The substantial lack of PGx knowledge among the healthcare workforce is the most frequently referenced key barrier to the integration and implementation of PGx in clinical settings[6] (i.e., less than 5% of physicians are familiar with PGx).[7] Global systematic reviews of the knowledge, attitudes, and practices of pharmacists[8] and doctors[9] regarding PGx/genetics revealed a lack of PGx knowledge and practice despite positive attitudes.

Educational interventions have been found to improve PGx knowledge and competency among healthcare professionals.[10] Furthermore, one of the six critical elements deemed indispensable for the successful implementation of PGx by SEAPharm member countries is structured PGx education. Existing data suggests that PGx education is either limited or lacking in the majority of SEAPharm member countries. Therefore, the development of structured PGx education should be prioritized in order to strengthen healthcare professionals and guarantee the effectiveness of PGx implementation. Capacity-building in Southeast Asia, including Malaysia, could potentially be achieved through the development of the PGx educational intervention.[5]

In Malaysia, Malaysia's Ministry of Health (MOH) developed a pharmaceutical program that represents the country's research priorities in 2018, which is currently considered a top priority for the Malaysian government.[11] Pharmacogenomics could be a crucial component in conducting some of the suggested research areas, as well as achieving their expected outcomes, such as the effectiveness of care and drug safety.[5] Moreover, two recent studies were conducted in Malaysia, one on medical and pharmacy students[12] and the other on community pharmacists.[13] Both studies[12,13] assessed the perceptions toward precision pharmacotherapy and PGx. The students' study[12] examined eight critical components of health sciences education, one of which was the impact of PGx on medication management. Furthermore, the study provided a roadmap for Malaysian medical and pharmacy students' perspectives on PGx and its implementation in precision pharmacotherapy, which should aid in enhancing the integration of genomics into clinical decision-making. The study also recommended updating curricula regarding genetic test results, interpreting and communicating test results, and updating training content to include ethical, legal, and social concerns related to PGx. Additionally, it recommended improving collaboration between academic and healthcare institutions, as well as governing bodies, to include additional training and education topics in PGx. The findings of the other study conducted on community pharmacists[13] were consistent with the findings of the students' study[12] in recommending adequate training focused on ethics, the use, and interpretation of PGx testing results to equip the pharmacists with the necessary knowledge to practice PGx.

Ultimately, despite the growth in research initiatives, interest in, and awareness of PGx, healthcare professionals (HCPs) continue to report a lack of knowledge, confidence, and preparedness in applying their PGx knowledge to patient care. This study aims to assess the current PGx knowledge gaps and learning needs of HCPs in Malaysia, as well as identify the competencies that HCPs should acquire on the basis of experts' judgment. As a result, the outcomes of the research will contribute to the development of a tailored, effective, evidence-based, competency-based educational intervention in PGx for healthcare professionals in Malaysia.

METHODS

A modified Delphi method with a multidisciplinary expert panel was conducted, in which two rounds were run to reach and gain a stable consensus. The panel experts were selected based on two predefined criteria: their authority and experience in the field of PGx and related subjects that apply PGx/genomics, including neurology, psychiatry, cardiology, pain management (rehabilitation and palliative care), oncology, nephrology (renal transplantation), clinical/hospital pharmacy, pharmacovigilance, and others. These experts included healthcare professionals from public/governmental and teaching hospitals, including clinicians and pharmacists, as well as academics/researchers from both public and private universities. The public hospitals covered in this study provide care at several levels, including secondary, tertiary, and specialized. Experts were identified based on the analysis of stakeholders and key opinion leaders in the field of PGx.[14,15] The study considered the experts' characteristics to tailor the PGx educational intervention to align with the current learning needs of the learners. Residents and interns were excluded.

The purposive sampling method was chosen, and the sample size was estimated to be 30 or more experts. Ethical approvals were received from the Medical Research and Ethics Committee (MREC), the Ministry of Health Malaysia (MOH), reference no. 23-00292-PWX, and subsequently, from each participating study site. A total of 14 study sites were included. The cut-off value was the value from which consensus was assumed and predefined as a threshold of 60% or higher. The consensus was measured using a percentage agreement. The Delphi round concluded once the predetermined threshold had been met for each survey item. Participation in the Delphi survey was voluntary. A quantitative descriptive statistical analysis was performed. A flow chart (Figure 1) illustrates the Delphi steps.

Delphi study process

Round one

The round one survey instrument, consisting of 21 items, was developed based on the findings of a systematic review of PGx education,[10] out of which three items used a preference scale. The preference scale is a scale similar to a Likert scale, where participants indicated their preference for survey items using the categories strongly preferred, moderately preferred, and equally preferred. Five experts validated the survey in terms of clarity and relevancy, achieving a satisfactory level of content validity (content validity index I-CVI = 0.94). The survey was subsequently pilot-tested by five experts before distribution. The survey items were developed in the Google form and divided into four sections apart from experts' demographics as follows: perception of PGx knowledge, perception of PGx practice, the context of PGx education, and expert recommendations/suggestions. The section on expert recommendations/suggestions is an open-ended question where any suggestion will be included in the next round

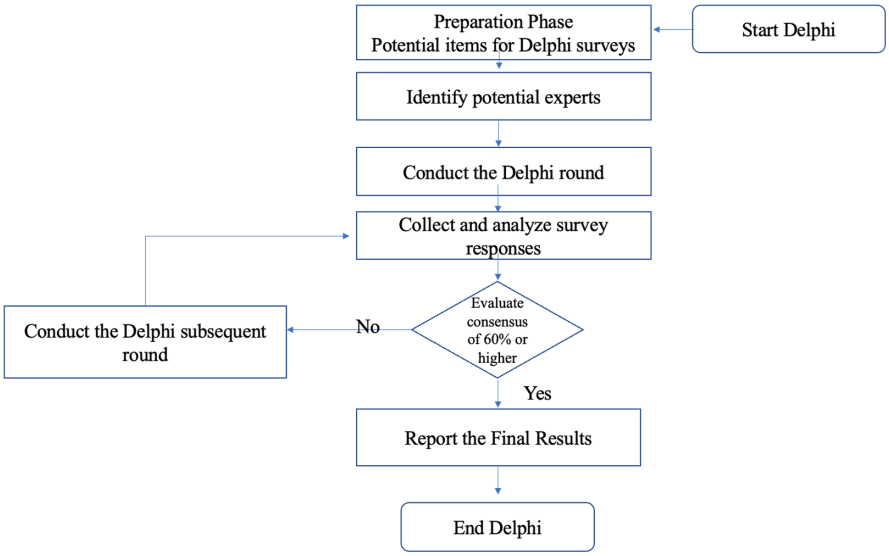

FIGURE 1 A flow chart illustrates the Delphi steps.

and evaluated by the experts for their level of agreement. This process continues until the experts no longer provide any new suggestions that differ from the survey items already given. At this point, the Delphi study concludes. The context of PGx education includes the content to be taught, the educational delivery approach to be employed, the faculty/provider responsible for teaching PGx, the target audience for education, the timing of educational delivery, strategies for motivating enrollment in PGx education, and the duration of the educational program. The findings of both sections of perception of PGx knowledge and practice, which indicated gaps in PGx understanding and its related concerns among healthcare professionals, were converted into educational components, which will be used to develop an educational intervention.

A briefing online meeting through Zoom was held for each study site, and interested experts were contacted by email and invited to participate in the Delphi process. Those who responded to the invitation and agreed to participate were provided with the link to the survey. Participants were asked to rate their agreement with each survey item; the neutral middle point was excluded to compel experts to choose a specific option. The survey was active and accessible for a duration of 1 month, from September 1 to 30, 2023, and participants were emailed weekly reminders to ensure completion. Each email was sent separately, and the use of an online survey guaranteed the maintenance of anonymity. Based on the responses and findings from the first round, it was determined that a second round was necessary.

Round two

A briefing online meeting through Zoom was held for each study site, and a video recording was sent to all the participants from the first round to explain the need and purpose for a second round. An email invitation to the second round was sent individually to the participants with a link to the second survey. The second survey was developed based on the items that did not reach the cut-off point in the first round, in addition to the items suggested by experts from the first round. Two experts reviewed the survey. The survey was active and accessible for a period of 1 month, from November 1 to 30, 2023, and participants were sent weekly reminders to ensure completion. The same analysis method was used as in the first round.

RESULTS

Round one

Experts' demographics for round one were summarized in Table 1. A total of 38 experts participated, 63.2% of whom were female, and 50% were between the ages of 31 and 40. More than 60% of the experts were HCPs; pharmacists made up the majority of the HCPs (60.5%). The majority of experts (76.3%) had postgraduate qualifications, and more than 80% had over 10% of experience. The most common practice specialities were hospital/clinical pharmacy, PGx/genomics, and neurology and psychiatry. A total of 18 items out of 21 approached or surpassed the agreement threshold of 60% (Table 2).

Perception of PGx knowledge

The panel agreed on five of seven items. All experts reached a consensus on the influence of PGx on treatment outcomes, such as optimizing medication efficacy and preventing ADEs. They strongly concurred that the lack of a training program that adequately prepares HCPs to practice PGx effectively is a significant contributor to the PGx knowledge

TABLE 1 Experts' demographics.

Characteristics	First round *N* = 38 (%)	Second round *N* = 34 (%)
Age		
31–40	19 (50%)	18 (53%)
41–50	11 (28.9%)	10 (29.4%)
>50	8 (21.1%)	6 (17.6%)
Gender		
Female	24 (63.2%)	22 (64.7%)
Male	14 (36.8%)	12 (35.3%)
Highest professional certificate/Qualification		
Undergraduate	9 (23.7%)	8 (23.5%)
Masters	15 (39.5%)	15 (44.1%)
Doctoral	14 (36.8%)	11 (32.4%)
Current practice position		
Healthcare professionals (HCPs)	25 (65.8%)	24 (70.6%)
Academic/Researcher	13 (34.2%)	10 (29.4%)
Practice speciality		
Medicine	10 (26.3%)	9 (26.5%)
Pharmacy	23 (60.5%)	23 (67.6%)
Other	5 (13.2%)	2 (5.9%)
Areas of expertise		
Pharmacogenomics/Genomics	11 (28.9%)	8 (23.5%)
Pharmacovigilance	1 (2.6%)	–
Hospital/Clinical pharmacy	19 (50%)	14 (41.2%)
Cardiology	3 (7.9%)	2 (5.9%)
Neurology & Psychiatry	6 (15.78%)	4 (11.8%)
Oncology	4 (10.5%)	1 (2.9%)
Pain management (Palliative care/ Rehabilitation)	3 (7.9%)	1 (2.9%)
Nephrology (Renal transplantation)	1 (2.6%)	1 (2.9%)
Other	6 (15.78%)	3 (8.8%)
Year of work/Teaching experiences		
1–5 years	2 (5.2%)	1 (2.9%)
6–10 years	5 (13.2%)	5 (14.7%)
More than 10 years	31 (81.6%)	28 (82.4%)

gap. The two items that did not meet the criterion of 60% demonstrated gaps in comprehending and differentiating the different terms and concepts associated with PGx.

Perception of PGx practice

Panel experts agreed that PGx is a multidisciplinary approach that can be applied in all health settings. They all reached a consensus that the high cost of genetic testing and services, as well as a lack of regulation governing PGx practice, are key barriers to adopting and implementing PGx in practice settings. Only one item did not meet the 60% agreement criteria. This item highlighted knowledge gaps in PGx-related concerns, specifically the social, legal, and ethical implications, such as genetic discrimination.

The context of PGx education and additional comments

The panel agreed on the importance of incorporating the PGx competency domains and a real patient case in the content delivered for educating HCPs. Furthermore, the

TABLE 2 Findings of round one.

Survey items	Results $N = 38\%$ Agreement
I. Perception of PGx knowledge	
1. Pharmacogenomics is a similar term to Precision Medicine	40%[a]
2. Pharmacogenomics is similar to Genomic Medicine	25.8%[a]
3. Malaysia is a multi-ethnic country; ethnic diversity reflects genetic and clinical response variation	100%
4. Genetic variation influences drug pharmacokinetics, pharmacodynamics, and responses	100%
5. PGx is only linked to genetic variations in drug-metabolizing enzymes such as CYP2C19	74.3%
6. Pharmacogenomics (PGx) employs genetic information to:	
a. Guide drug selection and regimen formulation	100%
b. Optimize medication safety and efficacy	100%
c. Cost-effectively prescribe medication in comparison to trial-and-error prescribing	100%
d. Reduce medication waste by using the right drug at the right dose	97%
e. Prevent adverse drug events (ADEs) and reduce the overall healthcare costs and deaths associated with ADEs, such as Carbamazepine associated with Stevens-Johnson syndrome (SJS)	100%
f. Reduce the occurrence of polypharmacy	77%
g. Improve drug discovery targeted to human diseases	94%
7. Gaps in/Lack of PGx knowledge are due to the following:	
a. Unclear understanding of PGx and its implications	100%
b. Absence of a training program that adequately prepares healthcare professionals to practice PGx	100%
c. Lack of standardized clinical guidelines to which to refer	97%
d. PGx is considered a complimentary clinical service	85.7%
II. Perception of PGx practice	
8. PGx practice is a risky clinical activity	68.5%
9. PGx implementation could lead to discrimination, stigmatization, and ineligibility for employment and insurance coverage	54.3%[a]
10. PGx is a multidisciplinary practice approach	100%
11. PGx can be practiced by all healthcare professionals regardless of speciality	62.9%
12. PGx is only practiced in hospital settings, regardless of the level of care	65.7%
13. PGx is applied to and practiced only for oncology patients	77.2%
14. Gaps in PGx practice: The major barriers to PGx practice:	
a. Lack of PGx knowledge among professionals	100%
b. High cost of genetic testing and providing genetic services or consultation	94%
c. Lack of funding, facilities, and devices	97%
d. Ethical, legal, social, religious, and clinical concerns	91%
e. Lack of national policy or guideline that regulates the PGx practice	100%
f. Patient acceptance to be genetically tested	80%
g. PGx competency is not a requirement for obtaining a license to practice healthcare	82.8%
III. The context of PGx education	
15 (A). What should be taught (What to teach)?	
a. Basic PGx concepts	100%
b. PGx competency domains such as ethical and legal implications	97%
c. Genetics and diseases	100%
d. A real patient case	100%
e. Indications and types of genotyping tests	100%
f. PGx guidelines and resources such as the Clinical Pharmacogenetics Implementation Consortium (CPIC)	94%

TABLE 2 (Continued)

Survey items	Results $N = 38\%$ Agreement
g. How to implement PGx in clinical settings and the roles of different healthcare professionals in PGx practice	97%
h. The implications of PGx practice on clinical and economic outcomes	97%
16 (B)[b] How should PGx be taught (How to teach)? The responses varied according to the expert preference level	
a. In-person, on-site learning	63.2%
b. Online learning	15.8%
c. Hybrid learning	36.8%
d. Interprofessional education	68.4%
e. Case-based discussion	81.6%
17 (C)[b] Who should provide PGx teaching (who should teach PGx)? The responses varied according to the expert preference level	
a. Academics/faculty members with PGx experience	68.4%
b. Geneticists; Genetic experts	68.4%
c. Pharmacogeneticist; Expert in PGx	84.2%
d. Industry pharmacy education provider	26.3%
e. Clinical pharmacist with PGx expert	65.8%
f. Clinician with PGx experience	71%
g. Genomic nurse	28.9%
18 (D) Who should be taught/educated?	
a. Medical doctors/clinicians	100%
b. Pharmacists in all settings	97%
c. Nursing staff	80%
d. All healthcare professionals, regardless of speciality	85.7%
e. Students in all healthcare professions, regardless of speciality	82.8%
19 (E) When should PGx be taught (when should the teaching be delivered)?	
a. Integrated within the undergrad curriculum	100%
b. Incorporated within residency/internship programs	94%
c. Included in postgraduate degree programs	94%
d. As a requirement for specializations in specific medical fields such as neurology, cardiology, and oncology	100%
e. As a mandatory requirement for all healthcare practitioners to acquire a license to practice in clinical settings	68.5%
f. As a continuing medical education (CME)	91.4%
20 (F)[b] How to motivate and encourage enrolment in PGx education and training? The responses varied according to the expert preference level	
a. Salary increase	68.5%
b. CME credits	68.5%
c. Certificate of completion and achievement	65.7%
d. Advancement in portfolio and career	78.9%
e. Incentives, such as vouchers and gifts	37%
21 (G) If educational training is to be provided for healthcare professionals, how long should PGx training take? Please select	
1–2 days	22.9%
A week	44.7%
Others (any alternative duration)	Varied

[a]Items were modified for more clarity and reviewed before adding them to the round two survey.

[b]Items used the preference scale: strongly preferred, moderately preferred, and equally preferred.

panel agreed that PGx should be integrated into the undergrad academic curricula and taught to all HCPs, regardless of their speciality, and as a requirement for specializations in specific medical fields, such as oncology. The preferred educational delivery approaches included case-based education ($n = 31$; 81.6%) and in-person ($n = 24$; 63.2%) interprofessional ($n = 26$; 68.4%) education. The preferred providers for a suggested PGx education/training were either those from academic backgrounds or HCPs, specifically physicians and pharmacists who have experience in PGx. The advancement in portfolio and career development ($n = 30$; 78.9%) served as a highly motivating method to encourage enrollment in PGx education. Seventeen experts (44.7%) determined that a duration of 1 week was optimal for delivering a PGx educational program.

Round two

A total of 34 experts participated. The demographics of the experts for the second round are presented in Table 1, and they are almost the same as for round one. Three items from the first round did not meet the criteria of 60% or above. These items were modified for more clarity and reviewed before distributing the round two survey. Furthermore, the experts suggested five additional items in the first round to be included. All eight items in round two met or exceeded the cut-off threshold of 60% (Table 3).

Perception of PGx knowledge

A consensus was reached by the panel that the lack of standardized teaching curricula for healthcare professionals across all universities is one of the contributing factors to the knowledge gap among practitioners regarding PGx.

Perception of PGx practice

An agreement was reached among experts on the barriers to the practice of PGx, such as the lack of a well-developed health system capable of integrating PGx data and providing clinical decision support and the lack of a standardized workflow for implementing PGx.

The context of PGx education and additional comments

The expert suggested including updates on national initiatives, research projects, and genetic mapping into the content of the provided educational intervention for healthcare professionals to integrate research into their professional work, from bench to bedside. On-demand approaches such as learning management systems (LMS), for example, Coursera, were suggested by the experts ($n = 20$; 58.8%) as one of the preferred delivery means. In round two, the experts made no additional suggestions that were different from the survey items already provided; hence, the Delphi study ended.

TABLE 3 Findings of round two.

Survey items	Results $N = 34\%$ Agreement
I. Perception of PGx knowledge	
1. Pharmacogenomics is one of the approaches to Precision Medicine	100%
2. Pharmacogenomics is an aspect of broader genomic medicine	100%
3. Gaps in/Lack of PGx knowledge are due to the following:	
a. The lack of standardized teaching curricula across all schools/universities of healthcare professionals	97%
II. Perception of PGx practice	
4. PGx Practice is a complex procedure	85.3%
5. PGx implementation could reveal an individual's disease/condition, resulting in discrimination, stigma, and ineligibility for health insurance and employment	70.6%
6. Gaps in PGx practice: The major barriers to PGx practice:	
a. Lack of standardized workflow for implementing PGx	100%
b. Lack of well-developed electronic health record (EHR) systems capable of integrating PGx data and providing clinical decision support	100
c. Lack of collaboration between healthcare professionals and PGx/genomic experts	100%
III. The context of PGx education	
A. What should be taught (What to teach)?	
7. The updates on national initiatives, research projects, and genetic mapping	85.3%
8 (B).[a] How should PGx be taught (How to teach)? The responses varied according to the expert preference level	
a. On-demand approaches such as learning management systems (LMS), for example, Coursera	58.8%
b. Learning groups and channels such as WhatsApp and Telegram	17.6%

[a]Items used the preference scale: strongly preferred, moderately preferred, and equally preferred.

DISCUSSION

This is the first Delphi study in which multiple study sites were included with a group of multidisciplinary experts in Malaysia. The participation of experts from many academic and professional fields provided a distinct viewpoint to the PGx, increasing the chances that its conclusions would be pertinent and practical in finding gaps in PGx knowledge and practice. This Delphi study provided a road map for designing an evidence-based and competency-based educational intervention for HCPs. Both sections of perception of PGx knowledge and practice aid in identifying the gaps regarding PGx understanding among healthcare professionals in Malaysia. While, the proposed context of PGx education will serve as a guide for developing a pragmatic and efficient instructional strategy.

The study's findings revealed that there is a limited understanding of various PGx terms and minimal awareness regarding PGx-related concerns among the panel. This indicates a need for focused education to enhance their PGx competencies. Therefore, it is critical to develop an educational intervention that emphasizes the fundamental PGx principles, such as genomics and precision medicine, alongside the pertinent considerations associated with PGx, including the ethical, societal, and legal implications. In order to practice PGx effectively, HCPs must possess the necessary qualifications and competencies in PGx to improve patient outcomes.[16]

In the context of PGx education, it is noteworthy that all the participating experts rated the content components as essential/important to be included in the educational intervention. These components are the necessary competencies required by a healthcare provider to carry out various tasks in genomic healthcare.[16] These competencies are listed by the American Association of Colleges of Pharmacies (AACP), and they consolidate and succinctly summarize the competencies established by the National Human Genome Research Institute (NHGRI) for healthcare disciplines in a comprehensive and simple way that can applied to all healthcare disciplines.[16] The AACP competency domains are four and include basic genetic concepts, genetics and disease, pharmacogenetics/pharmacogenomics (PGx), and ethical, legal, and social (ELS) implications.[17] It was found that the integration of PGx competency enhanced the learning experiences and outcomes, specifically in terms of knowledge, attitudes, and confidence in the clinical practice of PGx.[10] Moreover, these competencies are also the mandatory, accredited standards for the Professional Program in Pharmacy, which leads to the Doctor of Pharmacy Degree, as recognized by the Accreditation Council for Pharmacy Education (ACPE).[18] Therefore, it is crucial to integrate the PGx competency domains into educational interventions to enhance the practice of PGx in clinical settings.

The study found that experts were in favor of face-to-face, on-site, interprofessional, case-based education modality of learning. Given that PGx is a multidisciplinary practice approach,[19] the aforementioned preferred learning modality encourages disciplines to collaborate and engage in real-world settings, which is critical for the development of essential competencies, and professional and social responsibilities.[20] A case-based approach was determined to be effective in enhancing PGx understanding and practice, specifically in the interpretation and application of PGx findings in clinical settings.[10] Hence, the approach of providing an educational intervention should be developed in accordance with the learning needs. Additionally, experts agreed that PGx could be practiced by all HCPs, regardless of speciality, and recommended the integration of PGx into undergraduate curricula. This result aligns with the concluded recommendations of systematic reviews conducted among pharmacists[8] and doctors.[9] These reviews[8,9] emphasized the significance of early education for healthcare students and the integration of PGx into school curricula. Therefore, it would be prudent to educate and train healthcare students in advance during their academic years in order to equip them with the necessary knowledge and competencies to practice PGx.

Advancement in a career was rated as a highly encouraging approach to motivating healthcare professionals to enroll in educational training. Another study also reported a similar result, highlighting professional development and progress as a key motivational factor for healthcare professionals.[21] Therefore, a training plan should be developed taking into account the healthcare settings and motivational aspects for healthcare practitioners.

Experts highlighted three significant barriers to adopting and practicing PGx: the absence of national policy or guidelines regulating PGx practice and its associated concerns, the lack of reimbursement for PGx testing and genetic service provision, and the lack of a well-developed health system capable of integrating PGx data. The findings are consistent with the barriers listed by the SEAPharm research network.[5] This can be attributed to the lack of value recognition of the PGx's impact on the healthcare system by stakeholders, including policymakers and HCPs.[15] Therefore, to ensure the successful implementation of PGx in healthcare, it is critical to improve awareness and knowledge among all stakeholders regarding its significant impact.[22]

Future vision for PGx education for healthcare professionals in Malaysia

The future of PGx education for HCPs in Malaysia depends on the successful implementation of a comprehensive, evidence-based intervention that addresses the identified knowledge gaps. The findings of this Delphi study will serve as a guiding framework for developing a tailored, competency-based educational intervention in PGx. The proposed intervention will encompass core concepts of PGx, covering fundamental principles, terms, and definitions to ensure that all HCPs, regardless of speciality, have a solid understanding of PGx. Structured around the four competency domains defined by the American Association of Colleges of Pharmacy (AACP), the program will facilitate the acquisition of essential knowledge and skills required for effective PGx practice.

Considering the multidisciplinary nature of PGx, the intervention will incorporate interprofessional education (IPE), fostering collaboration among various HCPs and linking theoretical knowledge to clinical application through clinical case studies. Furthermore, the educational initiative will proactively address existing barriers to PGx implementation in Malaysia, such as the lack of national policies and reimbursement for PGx testing, while promoting the recognition of PGx's value among stakeholders to enhance its integration into the healthcare system. Engaging with local healthcare authorities and institutions will be essential in promoting collaboration and garnering support for the initiative, ensuring that it is aligned with national health priorities.

Acknowledging the motivational aspects of HCPs, the program will highlight how acquiring PGx competencies can lead to improved career advancement opportunities, which is crucial for encouraging participation. The ultimate goal is to bridge the knowledge gap in PGx among HCPs, enhancing their competence in implementing PGx in clinical settings and ultimately leading to better patient outcomes through personalized medicine. For instance, improving HCPs' understanding of PGx will lead to enhanced medication management, reduced adverse drug reactions and more effective treatment plans tailored to individual patient needs.

In terms of future directions, we aim to conduct a follow-up study to develop and deliver this educational intervention, assessing both its feasibility and effectiveness. This research will be critical in determining the impact of the intervention on HCPs' understanding and application of PGx, contributing to a more personalized approach to medicine in Malaysia and leading to better health outcomes. By evaluating the effectiveness of this intervention, we hope to establish a model that can be replicated in other regions, further expanding the reach and impact of PGx education.

Strengths and limitations

This is the first Delphi study conducted in Malaysia, involving various study sites and a panel of multidisciplinary experts. The participation of experts from diverse backgrounds offered a unique perspective to the PGx, enhancing the likelihood that its findings would be relevant and useful in pinpointing the PGx educational and policy requirements for healthcare professionals in Malaysia. The iterative process of the Delphi study enhances its strength. Moreover, employing an online survey guaranteed anonymity and enabled the collection of responses and analysis despite geographical constraints. The main limitation of the Delphi technique is that it is time-consuming; it took 5 months to complete. In addition, the purposive sampling method used is prone to research bias as the selection of experts might be based on a subjective judgment and may also be skewed toward pharmacists' opinions due to the nature of the PGx field. However, the study design is dependent on the predefined selection criteria of the expert panel.

CONCLUSION

This multisite Delphi study enabled the development of a tailored, effective, evidence-based, competency-based educational intervention in pharmacogenomics for healthcare professionals in Malaysia. The proposed context of pharmacogenomics education, including the content, provided healthcare professionals with the vital competencies required to practice pharmacogenomics in clinical settings. To keep up with the rapid evolution of the pharmacogenomics field, healthcare professionals should be equipped with the necessary competencies required to practice pharmacogenomics for better health outcomes. Future research is needed to determine the feasibility of the proposed educational intervention.

AUTHOR CONTRIBUTIONS

Safa Omran wrote the manuscript, designed the research, performed the research, and analyzed the data. Siew Lian Leong wrote the manuscript and designed the research. Ali Blebil wrote the manuscript. Devi Mohan wrote the manuscript and designed the research. Wei Chern Ang designed the Research. Siew Li Teoh wrote the manuscript and designed the research.

FUNDING INFORMATION

No funding was received for this work.

CONFLICT OF INTEREST STATEMENT

The authors declared no competing interests for this work.

ORCID

Safa Omran https://orcid.org/0000-0003-4097-5577
Siew Lian Leong https://orcid.org/0000-0002-2254-9358
Ali Blebil https://orcid.org/0000-0002-7480-1260
Devi Mohan https://orcid.org/0000-0002-0898-2729
Wei Chern Ang https://orcid.org/0000-0002-6599-3301
Siew Li Teoh https://orcid.org/0000-0003-4163-7895

REFERENCES

1. Hicks JK, Aquilante CL, Dunnenberger HM, et al. Precision pharmacotherapy: integrating pharmacogenomics into clinical pharmacy practice. *J Am Coll Clin Pharm*. 2019;2(3):303-313. doi:10.1002/jac5.1118
2. Michelle E, Klein MMP, Shin JG. Clinical implementation of pharmacogenomics for personalized precision medicine: barriers and solutions. *J Pharm Sci*. 2017;106:2368-2379. doi:10.1016/j.xphs.2017.04.051
3. Chandni Bardolia AM, Amin NS, Michaud V, Turgeon J, Bain KT. Utilizing pharmacogenomics to reduce adverse drug events. *Am J Biomed Sci Res*. 2020;11:258-261. doi:10.34297/AJBSR.2020.11.001638
4. Suarez-Kurtz G, Aklillu E, Saito Y, Somogyi AA. Conference report: pharmacogenomics in special populations at WCP2018. *Br J Clin Pharmacol*. 2019;85(3):467-475. doi:10.1111/bcp.13828
5. Chumnumwat S, Lu ZH, Sukasem C, et al. Southeast Asian Pharmacogenomics Research Network (SEAPharm): current status and perspectives. *Public Health Genomics*. 2019;22(3–4):132-139. doi:10.1159/000502916
6. Adesta F, Mahendra C, Junusmin KI, et al. Pharmacogenomics implementation training improves self-efficacy and competency to drive adoption in clinical practice. *Front Pharmacol*. 2021;12:684907. doi:10.3389/fphar.2021.684907
7. Cacabelos R, Naidoo V, Corzo L, Cacabelos N, Carril JC. Genophenotypic factors and pharmacogenomics in adverse drug reactions. *Int J Mol Sci*. 2021;22(24):13302. doi:10.3390/ijms222413302
8. Wondrasek A, Fryza A, Aziz MA, Leong C, Kowalec K, Maruf AA. Knowledge, perceptions, and attitudes toward pharmacogenomics among pharmacists and pharmacy students: a systematic review. *Health Sci Rep*. 2024;7(1):e1844. doi:10.1002/hsr2.1844
9. Ya'u A, Husain RB, Haque M. A systematic review of knowledge, attitude and practice towards pharmacogenomics among doctors. *Int J Pharm Res*. 2015;7(1):9-16.
10. Omran S, Leong SL, Blebil A, Mohan D, Teoh SL. Effectiveness of pharmacogenomics educational interventions on healthcare professionals and health professions students: a systematic review. *Res Soc Adm Pharm*. 2023;19(11):1399-1411. doi:10.1016/j.sapharm.2023.07.012
11. Ministry of Health Malaysia. Pharmacy research priorities in Malaysia. https://pharmacy.moh.gov.my/en/documents/pharmacy-research-priorities-malaysia.html. Accessed October 1, 2023.
12. Siamoglou S, Koromina M, Moy FM, Mitropoulou C, Patrinos GP, Vasileiou K. What do students in pharmacy and medicine think about pharmacogenomics and personalized medicine education? Awareness, attitudes, and perceptions in Malaysian health sciences. Survey/IMP only abstract. *Omics*. 2021;25(1):52-59. doi:10.1089/omi.2020.0178
13. Naimat F, Fahrni ML, Purushothaman S, Abdul Ghani MN, Chumnumwat S, Babar ZUD. Community pharmacists' perceived value on precision medicine, desired training components, and exposure during pharmacy education: Malaysia's experience. IMP/no educational intervention. *Front Pharmacol*. 2022;13:978141. doi:10.3389/fphar.2022.978141
14. Mitropoulou C, Mai Y, van Schaik RH, Vozikis A, Patrinos GP. Stakeholder analysis in pharmacogenomics and genomic medicine in Greece. *Public Health Genomics*. 2014;17(5–6):280-286. doi:10.1159/000365896
15. Chong HY, Allotey PA, Chaiyakunapruk N. Current landscape of personalized medicine adoption and implementation in Southeast Asia. *BMC Med Genomics*. 2018;11(1):94. doi:10.1186/s12920-018-0420-4
16. Institute NHGR. Discipline-specific genomic competencies. 2023. https://www.genome.gov/For-Health-Professionals/Provider-Genomics-Education-Resources/Competencies. Accessed October 1, 2023.
17. Roederer MW, Kuo GM, Kisor DF, et al. Pharmacogenomics competencies in pharmacy practice: a blueprint for change. *J Am Pharm Assoc (2003)*. 2017;57(1):120-125. doi:10.1016/j.japh.2016.08.014
18. Kisor D, Smith HE, Grace E, Johnson SG, Weitzel KW, Farrell CL. The DNA of pharmacy education: CAPE outcomes and pharmacogenomics. https://www.aacp.org/sites/default/files/2017-10/The_DNA_of_Pharmacy_Education-CAPE_Outcomes_and_Pharmacogenomics_2015.pdf. Accessed October 1, 2023.
19. White C, Scott R, Paul CL, Ackland SP. Pharmacogenomics in the era of personalised medicine. *Med J Aust*. 2022;217(10):510-513. doi:10.5694/mja2.51759
20. Frenk J, Chen LC, Chandran L, et al. Challenges and opportunities for educating health professionals after the COVID-19 pandemic. *Lancet*. 2022;400(10362):1539-1556. doi:10.1016/s0140-6736(22)02092-x
21. Vova-Chatzi M, Saridi M, Souliotis K. Motivation factors for continuing education of healthcare professionals. *Hellenic J Nurs Sci*. 2020;13:23-31. doi:10.24283/hjns.202013
22. Omran S, Hua GS, Teoh SL. *A Global Policy Review on Pharmacogenomics Practice: Carbamazepine-Based Therapy*. MUM School of Pharmacy; 2024.

How to cite this article: Omran S, Leong SL, Blebil A, Mohan D, Ang W, Teoh SL. The needs and gaps in pharmacogenomics knowledge and education among healthcare professionals in Malaysia: A multisite Delphi study. *Clin Transl Sci*. 2024;17:e70057. doi:10.1111/cts.70057