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Precision Medicine Readiness Among Malaysian Community Pharmacists: High Perceived Value, Moderate Knowledge, and Urgent Training Needs

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ABSTRACT

Precision medicine opens new possibilities for treatments tailored to an individual's genetic profile, lifestyle habits, and environmental factors. By merging molecular, pathological, and clinical diagnostic data, pharmacists can deliver more targeted pharmaceutical care. This work assessed community pharmacists' perceived value of precision medicine, their existing knowledge, and the training they believe is required. Across a 10-month period, a previously validated questionnaire—also made available online during the COVID-19 pandemic—was circulated in person, by email, and through social platforms. A total of 300 community pharmacists from 9 districts within a Malaysian urban state completed and returned the survey (75% response rate). Responses using three- or five-point Likert scales and multiple-choice items were analysed in SPSS to determine whether prior curricular exposure influenced knowledge, perceptions, and motivation to adopt precision medicine. Most participants were female (N = 196, 65.3%) and had ≤10 years of practice experience (N = 190, 66.3%). Knowledge levels were moderate (76%), yet respondents showed strong positive attitudes (94%), and 80% expressed readiness to incorporate precision medicine into daily practice. Although 61% reported no recollection of pharmacogenomics during their pharmacy education, the majority (93%) were open to further training. Preferred training areas included available pharmacogenetic tests (17%), interpretation of results (15%), and ethical issues (13%). Those with 0.5–10 years of experience demonstrated significantly higher knowledge ($\mu = 1.48$, CI 1.35–1.61, $p = 0.017$) than colleagues with 21–40 years in practice ($\mu = 1.28$, CI 1.05–1.51, $p = 0.021$). Educational exposure was associated with increased willingness to integrate precision medicine ($p = 0.035$). Community pharmacists showed strong interest in and appreciation for precision medicine. A substantial proportion reported previous encounters with precision-medicine concepts during their studies and were therefore inclined to apply them in routine healthcare delivery. With sufficient training in ethics, available pharmacogenetic tools, and result interpretation, pharmacists will be prepared to offer precision-medicine-related services in the near future.

Keywords: Pharmacogenomics, Pharmacogenetics, Pharmacist, Stakeholder, Precision medicine, Molecular diagnostics

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Introduction

Using pharmaceuticals selected according to an individual's genomic sequence has become central to advancing improved patient outcomes worldwide. In the United Kingdom [1], a recent position statement encouraged pharmacists to take a leading role in the upcoming pharmacogenomics era, further highlighting the usefulness of genomic testing. Rooted in the Precision Medicine Initiative, which involved a $215 million commitment from the United States government in 2016 [2], precision medicine was described as an emerging approach that incorporates variations in genetics, environment, and lifestyle to guide treatment and preventive strategies [3]. Like preventive medicine, it aims to shift healthcare from reactive to proactive through early detection and risk reduction [4].

When diagnosis is supported by detailed genomic information about individuals susceptible to disease, more effective treatment plans can be developed for specific conditions [4]. The terms precision, personalised, and individualised therapy have been used—sometimes interchangeably—over the past decade to denote treatment adjustment at a molecular level. Contemporary practice, however, tends to favour the term "precision." Regardless of terminology, genomics remains the foundation of both precision and personalised medicine [5].

Pharmacogenomics—merging pharmacology with genomics—is considered a central component of precision medicine. It examines how genetic makeup and other "omics" influence differences in drug response, ranging from reduced therapeutic effect to severe or even fatal adverse reactions [5]. Through genetic insights, primary care practitioners can more effectively tailor therapeutic choices, thereby improving patient selection and reducing the likelihood of adverse drug reactions by predicting beneficial treatment combinations [6].

The emerging shift is expected to markedly reshape prescribing behaviour and improve clinical outcomes. Pharmacists hold a distinct role in guiding appropriate medication selection and determining suitable doses [7]. Alongside physicians, laboratory personnel, and genetic counsellors, their duties include promoting appropriate use of pharmacogenomic testing, explaining and applying test findings, engaging in patient communication and interdisciplinary dialogue, optimising therapy based on genetic results, and incorporating pharmacogenomics into everyday clinical workflows [8]. Despite this, substantial variation remains in professionals' readiness to adopt precision medicine [9]. Compared with Western nations—especially the USA and Canada—where therapeutic drug monitoring combined with assessments of hepatic and renal function, genomic insights, environmental influences, and patient-specific factors has been used to guide therapy decisions [10], far fewer comparable investigations have been documented in South East Asia.

Healthcare professionals in the region showed limited preparedness and lacked enthusiasm to introduce precision medicine. Reluctance was primarily related to insufficient infrastructure and inadequate training in genomics. Research carried out in 2018 facilitated discussions among four South East Asian nations: Malaysia, Singapore, Thailand, and Indonesia. Results indicated that personalised medicine activities were more established in Singapore and Thailand, whereas Malaysia and Indonesia lagged behind [11]. The purpose of the present study was to examine community pharmacists' views on precision medicine, their level of understanding, and their willingness to incorporate it into practice.

Materials and Methods

Study design and sampling

A population-level investigation was undertaken among community pharmacists in Selangor, a western coastal state of Malaysia. Data were gathered over 10 months and across nine districts from September 2019 to June 2020. Selangor was chosen due to its large number of community pharmacies, public health facilities, and a comparatively high hospital-to-population ratio. Local regulations grant community pharmacists the authority necessary to perform standard pharmacy services. Of the 2,600 community pharmacies in the country, a substantial portion are situated in Selangor and are densely clustered in the Federal Territory of Kuala Lumpur and surrounding areas [12]. These outlets operated either as independent businesses or as part of larger chains [13].

A convenience-sampling approach was applied, distributing questionnaires to pharmacists who met both the inclusion and exclusion criteria. Eligible participants were those who had worked a minimum of 6 months in a community pharmacy listed with a postcode belonging to any of the nine districts, and both full-time and part-time practitioners were included. Pharmacists without Malaysian nationality were excluded. Participants received a written information sheet explaining the study's purpose, voluntary nature, and the anonymity of all responses. A cover letter accompanied the questionnaire, outlining consent details and instructions for completion and submission. Distribution occurred during in-person visits (68 in Klang, 33 in Kuala Selangor, 30 in Sabak Bernam, 22 in Kuala Langat, 23 in Hulu Selangor, 30 in Gombak, 36 in Petaling, 22 in Sepang, and 8 in Hulu Langat). Each pharmacist received the questionnaire, a pen, and a return envelope to maintain privacy. Previous research showed that face-to-face delivery yields high response rates [14]. Each survey required approximately 15–20 minutes to finish. Completed forms were sealed and could not be matched to individual respondents. Follow-up attempts were made for pharmacists absent during site visits. A tracking sheet documented serial numbers and the number of forms distributed and retrieved, without containing any identifiable information. Once the COVID-19

pandemic began, the remaining 128 potential participants were contacted via email and provided access to the questionnaire through Google Docs.

Using the Krejcie and Morgan formula [15], the required sample size was calculated as 297. To ensure adequate statistical power, 400 community pharmacists were targeted, anticipating a response rate of 50%.

$$s = X^2NP(1 - P) \div d^2(N - 1) + X^2P(1 - P) \quad (1)$$

s = the total number of participants required

X^2 = chi-square critical value for 1 degree of freedom at the chosen confidence level (3.841)

N = overall population size (1300), referring to the number of community pharmacies recorded in Klang Valley in 2000

P = estimated proportion of the population (set at 0.50 to yield the largest possible sample size)

d = allowable error margin, expressed as a proportion (0.05)

Measures or survey instruments

A frequently adopted and recently validated instrument for evaluating pharmacists' understanding, attitudes, concerns, expectations, and readiness to engage with pharmacogenomics is the 28-item survey created by AlEjielat *et al*. (2016). Since its release, it has been implemented in various countries, including by healthcare teams in Ethiopia and Egypt [16, 17], pharmacy students in the Netherlands [18], and pharmacist groups in Saudi Arabia [19] and Thailand [20]. The authors granted permission for its use.

The English form of the questionnaire was used, adapted where necessary, and uploaded to Google Docs so that respondents could complete it remotely—especially important during the COVID-19 lockdown, when direct, in-person data collection was impossible. The instrument was organised into six parts: (1) demographic details such as age, gender, ethnicity, experience, and highest qualification; (2) general knowledge; (3) self-rated knowledge; (4) perceived issues affecting practice; (5) previous and planned training in pharmacogenomics; and (6) willingness to apply the concept in the future. Knowledge was assessed using single-best-answer multiple-choice questions, while agreement ratings were used 3- or 5-point Likert scales from "strongly disagree" to "strongly agree."

Primary endpoints

The major study outcomes included: (1) objectively measured and self-reported knowledge; (2) pharmacists' perception of pharmacogenomics; (3) whether pharmacy school had exposed them to the topic; (4) interest in further training and which components of precision medicine education they considered important; and (5) readiness to incorporate pharmacogenomics into current practice. For endpoint 1, multiple-choice scores of 4 or higher signified good knowledge, a score of 3 represented moderate understanding, and scores below 3 indicated limited knowledge. For self-assessment using a 3-point Likert scale, agreement with 4 or more items was classified as good, agreement with 3 as moderate, and agreement with 2 or fewer as poor. For endpoint 2, using a 5-point scale, agreeing/strongly agreeing with at least 7 items reflected a positive perception; fewer than 7 indicated a negative one. For endpoint 3, selecting agree/strongly agree on the 5-point scale denoted prior exposure. For endpoint 4, the same response pattern indicated willingness to pursue training. For endpoint 5, respondents who answered "yes" to at least 5 items from the "yes/no/not sure" options were considered willing to adopt precision medicine; others were placed in the not-willing category.

Statistical analyses

Analyses were performed using SPSS® version 23 for Windows® (IBM Corporation, Armonk, New York, United States). Participants' characteristics and item-level results were summarised as frequencies and percentages. Items worded negatively were reverse-coded. Because the dataset did not meet normality assumptions, associations between demographic variables and rank-based scores for knowledge, perception, and willingness were examined using Mann–Whitney U and Kruskal–Wallis tests. When significant differences were detected, Dunn's post-hoc test with a Bonferroni adjustment was applied. A p-value of 0.05 served as the significance threshold for all tests except the post-hoc analysis, which used a stricter p-value of 0.025.

Ethical consideration

Approval for the study was obtained from the University's Research Ethics Committee (REC) prior to data collection.

Results and Discussion

Demographic characteristics

Out of the 400 questionnaires distributed to community pharmacists—both digitally and in person—300 were returned completed, yielding a 75% response rate. All analyses were based on these 300 responses. **Table 1** presents the participants' demographic information.

Table 1. Sociodemographic characteristics.

Characteristic	N = 300	Percentage (%)
Gender		
Male	104	34.7
Female	196	65.3
Age group (years)		
21–30	134	44.7
31–40	86	28.7
41–50	58	19.3
51–60	18	6.0
>60	4	1.3
Ethnicity		
Malay	51	17.0
Chinese	225	75.0
Indian	21	7.0
Others	3	1.0
Years of practice as community pharmacist		
0–10 years	190	66.3
11–20 years	79	26.3
21–30 years	27	9.0
31–40 years	4	1.3
Highest educational qualification		
Bachelor's degree	240	80.0
Master's degree	60	20.0
District of practice (Selangor state)		
Gombak	28	9.3
Hulu Langat	50	16.7
Hulu Selangor	21	7.0
Klang	64	21.3
Kuala Langat	22	7.3
Kuala Selangor	13	4.3
Petaling	64	21.3
Sabak Bernam	11	3.7
Sepang	27	9.0

Females made up over half of the sample (N = 196, 65.3%). Most respondents had been practising for an average of 6.2 years and were concentrated in the "0.5–10 years" experience group (N = 190, 66.3%). A notable proportion were aged 30 or younger (N = 134, 44.7%) and had spent at least six months working in a community pharmacy located in one of the nine Selangor districts. Klang and Petaling were the two districts with the highest participation (N = 64, 21.3% each).

Knowledge

General knowledge on precision medicine and pharmacogenomics

Most pharmacists (76.3%) demonstrated a moderate understanding of precision medicine and pharmacogenomics **(Table 2)**. Nearly all respondents (95%) correctly identified that "Pharmacogenomics is an integral part of precision medicine and merges pharmacology with genomic science." However, many were unsure about the availability of pharmacogenetic tests for most drugs in Malaysia. The statement, "Genetic factors influencing a person's drug response may change during their lifetime," was frequently misunderstood.

Table 2. General knowledge of precision medicine and pharmacogenomics.

Statement	True	False	I do not know
	n (%)	n (%)	n (%)
1. Precision medicine refers to prevention, diagnosis, and treatment strategies that account for individual differences	261 (87.0%)	13 (4.3%)	26 (8.7%)
2. Precision medicine only considers genetic variations and excludes environmental and lifestyle factors	71 (23.7%)	180 (60.0%)	49 (16.3%)
3. Pharmacogenomics, which combines pharmacology and genomics, is a core component of precision medicine	285 (95.0%)	3 (1.0%)	12 (4.0%)
4. Pharmacogenetic testing is currently available for most medications in Malaysia	48 (16.0%)	101 (33.7%)	151 (50.3%)
5. A person's genetic determinants of drug response can change over their lifetime	199 (66.3%)	42 (14.0%)	59 (19.7%)

Self-assessed knowledge on precision medicine and pharmacogenomics

When rating their own knowledge, respondents were largely uncertain, with 42.7%, 39%, 36.7%, and 45.3% choosing "neutral" for four of the five items. The final item—"Additional information on precision medicine and pharmacogenomics can be easily found online"—received agreement from roughly half (49%) **(Table 3)**. In summary, 53.7% judged their self-knowledge as poor, 34.7% viewed themselves as moderately informed, and a small portion (11.7%) considered themselves knowledgeable.

Table 3. Self-assessment of knowledge.

Statement	Yes / Agree	No / Disagree	Not sure / Neutral
	n (%)	n (%)	n (%)
I am aware of the pharmacogenetic tests currently available in Malaysia	50 (16.7%)	122 (40.7%)	128 (42.7%)
As a community pharmacist, I feel well-prepared to discuss pharmacogenetic information with other healthcare professionals (doctors, nurses, etc.)	92 (30.7%)	91 (30.3%)	117 (39.0%)
As a community pharmacist, I can accurately apply pharmacogenetic test results to drug therapy selection, dosing, and monitoring	101 (33.7%)	89 (29.7%)	110 (36.7%)
I can identify medications for which pharmacogenetic testing is recommended	84 (28.0%)	80 (26.7%)	136 (45.3%)
Additional information on precision medicine and pharmacogenomics is easily accessible online	147 (49.0%)	37 (12.3%)	116 (38.7%)

Perception

Perception towards the practice of precision medicine and pharmacogenomics

Overall, 94% exhibited a positive perception toward precision medicine, while 6% did not. Most respondents (83.3%) believed precision medicine is relevant to the responsibilities of community pharmacists. Slightly fewer (80.3%) felt it could reduce adverse drug reactions, and 72% perceived that using precision medicine could enhance drug efficacy. About half (48.4%) expressed concern that a patient's pharmacogenetic results might be shared with unauthorized individuals, and 57% were apprehensive that such results might reveal unsuspected disease risks (e.g., Alzheimer's or cancer) **(Table 4)**.

Table 4. Perception towards the practice.

Statement (Perception of precision medicine/pharmacogenomics)	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	n (%)	n (%)	n (%)	n (%)	n (%)
1. Precision medicine plays an important role in my profession as a community pharmacist	0 (0%)	4 (1.3%)	46 (15.3%)	196 (65.3%)	54 (18.0%)
2. Implementing precision medicine in community pharmacy will bring positive outcomes to my practice	0 (0%)	4 (1.3%)	39 (13.0%)	192 (64.0%)	65 (21.7%)
3. Use of precision medicine by community pharmacists will reduce the number of adverse drug reactions	0 (0%)	2 (0.7%)	57 (19.0%)	165 (55.0%)	76 (25.3%)
4. Implementing precision medicine in community pharmacy will improve drug efficacy in patients	1 (0.3%)	5 (1.7%)	78 (26.0%)	149 (49.7%)	67 (22.3%)
5. Pharmacogenomics and precision medicine are relevant to my primary care/community pharmacy setting	0 (0%)	10 (3.3%)	86 (28.7%)	162 (54.0%)	42 (14.0%)
6. Pharmacogenomics and precision medicine help optimise drug dosing in community pharmacy practice	0 (0%)	8 (2.7%)	106 (35.3%)	138 (46.0%)	48 (16.0%)
7. Counselling patients on pharmacogenetic information is part of a community pharmacist's role in precision medicine	0 (0%)	6 (2.0%)	46 (15.3%)	188 (62.7%)	60 (20.0%)
8. I am concerned that a patient's pharmacogenetic test results could be disclosed to unauthorised persons	8 (2.7%)	49 (16.3%)	98 (32.7%)	98 (32.7%)	47 (15.7%)
9. I am worried that pharmacogenetic testing may reveal risk factors for other serious diseases (e.g., Alzheimer's, cancer) the patient is unaware of	4 (1.3%)	46 (15.3%)	80 (26.7%)	134 (44.7%)	36 (12.0%)
10. An unfavourable pharmacogenetic test result may cause adverse psychological effects on the patient and their family	5 (1.7%)	34 (11.3%)	97 (32.3%)	128 (42.7%)	36 (12.0%)

Willingness

Willingness to implement precision medicine and pharmacogenomics

While many acknowledged that they currently do not provide adequate patient counseling on precision medicine (57.3%), substantial majorities were open to using genome-based tools (85.7%), offering pharmacogenetic testing (80%), and delivering related precision medicine services (88.3%). Reported barriers included limited time, insufficient funds, and inadequate training **(Table 5)**. Nevertheless, 80% indicated a willingness to adopt precision medicine in practice.

Table 5. Willingness to implement.

Statements Evaluating Readiness to Adopt	Yes	No	Not sure
1. As a community pharmacist, I am prepared to use precision medicine, pharmacogenomics, and genome-informed tools when delivering medications and related services.	257 (85.7%)	6 (2.0%)	37 (12.3%)

2. I am open to providing pharmacogenetic testing and counselling as part of the service portfolio in my community pharmacy.	240 (80.0%)	8 (2.7%)	52 (17.3%)
3. Should precision medicine services become standard practice in the future, I would be interested in taking on the role of a precision medicine provider.	265 (88.3%)	1 (0.3%)	34 (11.3%)
4. In my current role, I believe I devote an adequate amount of time to discussing precision medicine with my patients.	69 (23.0%)	172 (57.3%)	59 (19.7%)
5. I anticipate having sufficient time in the future to incorporate precision medicine services into my responsibilities as a community pharmacist.	144 (48.0%)	33 (11.0%)	123 (41.0%)
6. I routinely review journal articles or publications related to precision medicine and pharmacogenomics.	64 (21.3%)	181 (60.3%)	55 (18.3%)
7. Insufficient training is likely to be a major obstacle to implementing precision medicine within community pharmacy settings.	266 (88.7%)	3 (1.0%)	31 (10.3%)
8. Delivering precision medicine services in community pharmacies would require substantial financial resources.	163 (54.3%)	43 (14.3%)	94 (31.3%)

Prior exposure

Exposure to pharmacogenomics in undergraduate curricula, willingness to undergo training, and preferred precision medicine components

A large share of community pharmacists reported little or no recollection of learning about pharmacogenomics during their university education (61%). Despite this, an overwhelming majority (93%) expressed interest in pursuing further training in precision medicine **(Table 6)**.

Table 6. Exposure and training willingness.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
I received training on precision medicine and pharmacogenomics during my pharmacy curriculum	19 (6.3%)	67 (22.3%)	97 (32.3%)	100 (33.3%)	17 (5.7%)	300 (100%)
I am willing to undergo additional training to gain knowledge in precision medicine and pharmacogenomics	0 (0%)	0 (0%)	21 (7.0%)	191 (63.7%)	88 (29.3%)	300 (100%)

Among the eight precision medicine components offered as training options, the most frequently selected was learning about available pharmacogenetic tests (17.1%), followed by gaining skills in interpreting test results (15.2%), and then understanding ethical issues. The least chosen topic was the cytochrome P450 (CYP450) system and transporter mechanisms (6.8%) **(Figure 1)**.

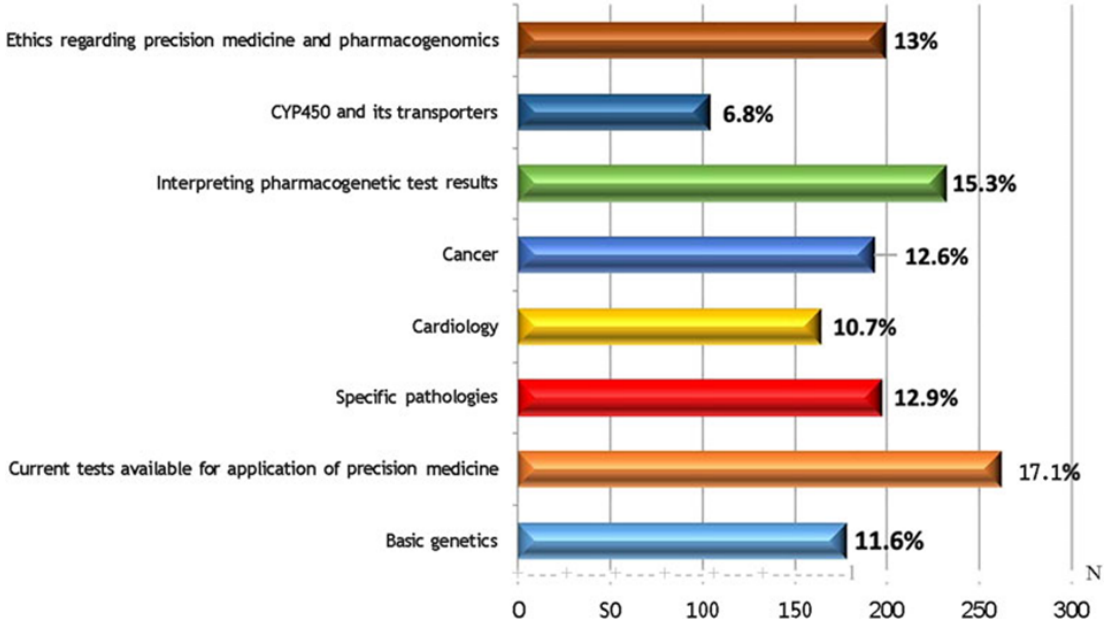

Figure 1. Components of Precision Medicine Viewed as Necessary for Training.

Differences in knowledge, perception, and willingness to practice

No statistically significant relationships were identified between any sociodemographic variable and pharmacists' perception or willingness to practice. However, stronger general knowledge of precision medicine showed a significant association with years of professional experience [H(3), p = 0.004]. Additional ANOVA analyses comparing total knowledge scores among the "0.5–10 years," "11–20 years," and "21–40 years" groups also demonstrated significance [F (2, 195) = 4.146, p = 0.045]. Bonferroni-adjusted post hoc results (significance threshold = 0.025) indicated that pharmacists with 0.5–10 years of experience reported notably higher knowledge (μ = 1.48, CI 1.35–1.61, p = 0.017) compared with those in the 21–40 years category (μ = 1.28, CI 1.05–1.51, p = 0.021). No meaningful differences were detected between the remaining experience groups.

Differences in willingness to practice, and prior exposure to pharmacogenomics during pharmacy education

Pharmacists who had encountered pharmacogenomics in their university training were more willing to incorporate precision medicine into routine practice than those who had not, or who indicated they were unsure about such exposure (mean rank = 214.3, U = 337.5, p = 0.038).

Survey response rate

Using a combination of printed questionnaires and email distribution during the early period of the COVID-19 pandemic produced a relatively strong response rate of 75%. Notably, emailing the survey as an attached file—rather than embedding a hyperlink—appeared effective in increasing participation. Although phone calls and postal mail have long been used in research, recent years, particularly the last two, have seen substantial growth in the use of online survey methods [21].

Barriers to implementing precision medicine

The findings suggest that knowledge levels remain limited, reflecting the early developmental stage of precision medicine in many low- and middle-income nations [22]. Consistent with this study's results—where pharmacists generally held favourable perceptions and moderate enthusiasm toward precision medicine—earlier work has shown strong conceptual acceptance of precision medicine and pharmacogenomics among primary healthcare providers, including physicians and pharmacists [23–25]. Despite this, earlier adoption was slow, though future uptake was widely viewed as promising [26, 27]. A common obstacle across studies was insufficient knowledge and skill among clinicians, an issue echoed here, where many pharmacists acknowledged their own limited understanding. Comparable outcomes have been documented in Nigeria and Thailand [20, 28]. More economically advanced regions—such as China, Japan, India, and Middle Eastern countries including Qatar,

Saudi Arabia, and Kuwait—have shown greater readiness to integrate precision medicine into clinical workflows [29, 30].

One major contributor to lower uptake in low- and middle-income countries is the added financial burden of pharmacogenetic testing. In settings with restricted healthcare budgets, implementing testing-based personalised care is difficult [31]. A study from the National University of Malaysia highlighted cost-related challenges in establishing precision medicine practices: genetic and genotyping tests may range from MYR2000 to RM5000 (up to USD 1130), and these costs are not covered by national health funding. Additionally, tyrosine kinase inhibitors—often central to precision medicine treatment—are not included in the Ministry of Health formulary, meaning patients must pay out-of-pocket, increasing their financial burden. There is also concern internationally that genetic results may influence eligibility for insurance coverage, although such policies do not currently apply in Malaysia.

In this study, pharmacists with 0.5–10 years of experience displayed a stronger understanding of precision medicine compared with their more seasoned colleagues. This may be due to more recent education or greater reinforcement of concepts early in their career. Similar conclusions were observed in Romania by Pop *et al*. (2022) [32]. Findings from the Southeast Asian Pharmacogenomics Research Network (SEAPHARM) have shown that Malaysia includes foundational genetics and pharmacogenomics within its national pharmacy curriculum, complemented by opportunities for continuing professional development—such as postgraduate courses, conferences, workshops, and online learning [33]. Nonetheless, substantial variability in knowledge remains across community pharmacists, which may contribute to lower overall knowledge scores [34].

Many pharmacists either disagreed or remained neutral regarding their ability to communicate pharmacogenetic information with other health professionals or apply genetic test outcomes to current therapeutic decisions, likely due to perceived lack of preparedness. Thus, a structured environment that supports ongoing training in pharmacogenomics—promoting awareness and strengthening competency among community pharmacists—could facilitate the broader adoption of precision medicine in Malaysia in the future.

Role of precision medicine and pharmacogenomics in pharmacy school curriculum and willingness of community pharmacists to undergo training

One possible contributor to the limited grasp of precision medicine and pharmacogenomics is the lack of exposure to these subjects during undergraduate pharmacy training. Findings from this study indicated that a considerable portion of respondents had encountered some instruction related to these topics earlier in their pharmacy education, which appeared to influence their readiness to learn more and advance in this area. McMahon (2011) [35] examined how Australian pharmacists perceived pharmacogenetics and found that overall familiarity was low, with more recent graduates demonstrating a stronger understanding compared with pharmacists who had been practicing longer. In Saudi Arabia, interest among pharmacy students in applying pharmacogenomic testing in clinical settings was also modest, highlighting the need for revised curricula that incorporate contemporary pharmacogenomics-oriented health education.

A central role of community pharmacists in pharmacogenomics is helping facilitate the appropriate use of available tests and explaining their clinical consequences to peers, other healthcare professionals, patients, and the general population [23]. In this study, many community pharmacists expressed willingness to integrate pharmacogenetic testing and related counselling as part of extended pharmaceutical services and were eager to take on a provider role for precision medicine. According to survey responses, the two areas they most wished to be trained in were currently available pharmacogenetic test options and how to interpret the resulting data. Ethical considerations surrounding precision medicine followed as the next priority, whereas training on cytochrome P450 enzymes and transporters was the least selected topic.

Within modern outcome-based educational systems, backward design is frequently used to determine which content, activities, or training strategies should be included in courses, workshops, webinars, or conferences to support learners in achieving required competencies. In the field of pharmacogenomics, various competency frameworks have been proposed [25, 36]. The American Association of Colleges of Pharmacy (AACP), for example, outlines a structured set of core competencies grouped into foundational genetic principles and clinical pharmacogenomics (CP). These are built upon six domains of entrustable professional activities (EPAs): 1) patient care provider, 2) interprofessional collaborator, 3) promoter of population health, 4) information specialist, 5) practice manager, and 6) self-developer [37]. Although some EPA components are tailored to the U.S. pharmacy system, they can still serve as a guide when establishing learning goals for both pharmacy curricula and continuing

professional education. Adjusting these outcomes to reflect country-specific needs—such as healthcare policy constraints, reimbursement structures, or availability of pharmacogenetic testing—allows for better prioritisation of content. As such, pharmacogenomics training programmes for pharmacy students and community pharmacists, including those in this study who expressed enthusiasm for additional learning, can be more effectively designed.

Strengths and limitations

Because purposive sampling was used, the study focused on community pharmacists working in the most economically developed state in Malaysia. Even though the response rate was fairly high and the selected locations were heavily populated with community pharmacies, the resulting sample may not accurately reflect the national pharmacist population. Consequently, the interpretations drawn from the results may be applicable primarily to practitioners in that region. For example, pharmacists practicing in less economically advantaged areas may consider pharmacogenomics and associated services financially burdensome. Future investigations should broaden the sampling strategy—such as adopting systematic random sampling—to achieve a sample that more closely represents the national landscape.

Conclusion

Community pharmacists generally demonstrated openness toward and appreciation for precision medicine. A substantial portion had already encountered related concepts during their pharmacy education, which appeared to enhance their willingness to adopt and integrate such practices into routine care. With targeted training focused on ethical considerations, proper use of pharmacogenetic testing, and interpretation of results, community pharmacists could become well-prepared to deliver precision medicine services in the near future. Thus, structured and continuous professional development programmes that emphasize practical skill building are likely to support the wider integration of precision medicine within pharmacy practice.

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