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Original Research Article

Bridging genomic medicine and clinical practice: a cross-sectional analysis of knowledge, attitudes, and implementation of genetically tailored pharmacotherapy among doctors in a tertiary care hospital

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ABSTRACT

Background: Pharmacogenomics is the study of how genetic variation influences drug response, impacting both efficacy and safety. It explains interindividual differences in drug action sometimes accounting for up to 95% of variability and has roots in discoveries like glucose-6-phosphate dehydrogenase deficiency related haemolysis with primaquine. By enabling personalized medicine, pharmacogenomics can optimize therapy, minimize adverse effects, and guide drug development. Despite its promise, challenges remain in genetic testing validity and defining clinical utility, especially for complex genes like CYP2D6.
Methods: This cross-sectional KAP study at Mysore Medical College and Research Institute surveyed doctors using a 25-item validated Google form questionnaire (6 demographic, 6 knowledge, 5 attitude, and 8 practice questions), with digital informed consent and ethical clearance. Data were distributed via WhatsApp groups, cleaned, and analysed using descriptive statistics across all domains.
Results: A total of 110 medical professionals participated in the survey. Awareness of the term pharmacogenomic testing was high (87.3%), but self-rated knowledge was mostly poor to fair (61.8%), and familiarity with major resources such as Clinical Pharmacogenetics Implementation Consortium (CPIC) and PharmGKB was limited (>60% reporting poor awareness). Attitudes were largely positive, with more than half agreeing that pharmacogenomic testing can optimize drug choice and dosing and improve efficacy while reducing adverse drug reactions. However, practical use was low: only 12.7% reported institutional test availability and 81.8% had never recommended testing. Most respondents rarely or never discussed pharmacogenomics with patients (65.4%).
Conclusion: Overall, a significant gap exists between awareness and implementation, indicating a need for improved education, institutional support, and access to testing.

Keywords: Pharmacogenomics, Doctors, Knowledge, Attitude, Practice

INTRODUCTION

Pharmacogenomics is defined as the study of how an individual's genetic makeup influences their response to drugs, affecting both efficacy and safety. By identifying genetic variations that impact drug response, pharmacogenomics enables personalized medicine, optimizing treatment outcomes and minimizing adverse effects.[1,2] It is widely recognized that genetic variation plays a key role in the differences observed in disease phenotypes and drug responses, which is reflected in the widely reported efficacy rates for various drugs, ranging from 25% to 80%. For certain medications, genetic information has clear implications for guiding therapy to minimize toxicity and maximize therapeutic response.[3-5] Furthermore, understanding the genetic factors that drive variability in drug response offers a valuable tool in drug development, potentially reducing unexpected adverse

effects, identifying the patients most likely to benefit, and making the development process more efficient.[6]

Plasma drug concentrations can differ by more than 600-fold between two individuals of the same weight receiving identical dosages. This variability may stem from genetic, physiological, pathophysiological, or environmental factors. However, a drug's absorption, distribution, metabolism, and interaction with its target can all be influenced by genetic differences. Generally, genetic factors are estimated to explain 15%–30% of interindividual differences in drug metabolism and response, but for specific drugs or drug classes, genetics can account for up to 95% of the observed variability.[4,5,7]

The concept that genetic factors determine drug response by altering pharmacokinetics and pharmacodynamics dates back to the late 1950s, when it was discovered that an inherited deficiency of glucose-6-phosphate dehydrogenase caused severe haemolysis in some patients treated with the antimalarial drug primaquine.[8] This finding clarified why haemolysis was predominantly seen in African-Americans, where the deficiency is more common, and rarely in Caucasians from Northern, Western, and Eastern Europe. The term pharmacogenomics was later adopted to signify the shift from single-gene genetics to genome-wide approaches in identifying genes contributing to specific diseases or drug responses. By using pharmacogenomics, drug therapy can be tailored to genetically defined patient subgroups and may even lead to molecular-level reclassification of diseases and treatments. Additionally, discovering new disease-related genes may uncover novel drug targets. For the 30,000 known diseases, including 100 to 150 major common disorders, effective or improved drug therapies are still lacking.[9]

Genetic variants affecting the clinical outcomes of certain medications can now be reliably tested in clinical practice. Prescribing decisions for clinically actionable gene–drug pairs should take these genetic test results into account. Prior to clinical use, genetic tests must meet standards regarding analytical validity, clinical validity, and clinical utility.[10] Developing tests with reliable analytical validity is particularly challenging for pharmacogenes like CYP2D6, due to germline copy number variations and hybrid gene fusions that complicate assay interpretation. Assessing clinical utility involves determining whether testing improves patient health outcomes, while also considering potential risks associated with testing. Opinions vary widely on which outcomes define clinical utility.[11–13] Some studies extend this assessment to the broader health-care system, evaluating the costs of genetic testing relative to other interventions and examining how such testing might influence clinician behaviour.

Knowledge, attitudes, and practices (KAP) surveys are commonly used to assess what a defined professional population knows, believes, and does in relation to a health/clinical topic, and the methodological approach taken here follows standard KAP practice and reporting principles.[14] Multiple KAP surveys and studies have been carried out to assess, understand, and implement the use of pharmacogenomics (PGx) in the clinical settings of a few countries.[12,13,15] From the perspectives of healthcare, medicine, and ethnic diversity, such studies hold particular significance for a developing country like India.[16,17] Being a populous nation with extensive ethnic variation stemming from differences in genetic ancestry, pharmacogenetic research on specific Indian ethnic groups can enhance the effectiveness of PGx tests and contribute to expanding knowledge in the field.[18] Conducting KAP studies can assist in formulating strategic plans, developing a skilled workforce, and implementing cost-effective solutions, while ensuring patient safety and privacy.[19,20] In this context, we designed a KAP study on PGx among doctors working at a tertiary hospital in Mysore, influencing current understanding of PGx. Our study group reflects healthcare practitioners practicing in a major metropolitan area of India.

METHODS

The study employed a cross-sectional KAP study design conducted in Mysore medical college and Research Institute, during the study period from April 2025 to September 2025. The target population for this study comprised resident doctors, consultants, super-specialists, and resident medical officers (RMOs) working across every specialty and super-specialty department of the tertiary care hospital. Participation was voluntary and limited to medical staff present and eligible during the data collection period. All eligible and consenting doctors present during the data collection window were invited to participate, yielding a convenience (available-staff) sample of the hospital workforce.

The questionnaire was administered in the form of a Google Form and consisted of a total of 25 items: 6 questions on basic and demographic details, 6 questions assessing knowledge, 5 questions assessing attitude, and 8 questions assessing practice. Digital informed consent was obtained at the beginning of the Google form before respondents could proceed to the questionnaire items. The consent statement briefly described the study purpose, voluntary nature of participation, data confidentiality, approximate time required, and contact information for the investigators.

Questionnaire development followed the survey objectives and was structured so that demography, knowledge, attitude, and practice domains could be separately analysed. The composition and number of items in each domain were chosen to provide broad coverage of demographic variables and to capture core elements of knowledge, attitude, and practice relevant to the study aim. The questionnaire content was derived from an evidence-based review of the literature and adapted to the local clinical context by the study team. Content validity was evaluated by a panel of senior clinicians and

pharmacologists from relevant specialties; suggested revisions from the panel were incorporated prior to fielding.

Ethical committee clearance was obtained from the institutional ethics committee before initiating data collection.

Data collection procedures

The instrument was hosted on Google forms and made available to the target participants during the defined study period. Responses were recorded electronically and exported to a spreadsheet for cleaning and analysis. The Google form link was distributed through inter and intra departmental WhatsApp groups so as to reach doctors across specialties.

Exported responses were screened for duplicates, incomplete submissions, and obvious data entry errors. Data cleaning steps included removal of duplicate submissions, logical checks for inconsistent answers, and coding of categorical responses into numerical values for analysis. The final cleaned dataset was locked prior to analysis.

Scoring and analysis

KAP items were analysed individually as categorical or frequency data. Descriptive statistics (means and standard deviations for continuous variables; frequencies and percentages for categorical variables) were used to summarise respondent characteristics and domain scores.

We aimed to minimize bias during questionnaire design and administration, for example by using straightforward question wording and closed-ended items where appropriate, and by embedding the consent and instructions clearly at the start of the form. However, as with all KAP surveys, findings are subject to limitations including self-report bias, social desirability bias, and the cross-sectional nature of the data which limits causal inference. Rigorous reporting and transparency about these limitations help contextualize results for readers.

RESULTS

A total of 110 participants completed the survey.

Participant characteristics

Of the respondents, 52 (52.7%) were males and 58 (47.3%) were females. Participants' ages ranged mainly between 26 and 36 years, with the highest proportion being 28 years old (36 respondents, 32.7%), followed by 27 years (28 respondents, 25.5%). 76 (69.1%) participants were post graduates and 34(30.9%) participants were specialists. No participants held DM/MCh or other qualifications. All respondents were affiliated with Mysore Medical College and Research Institute (Table 1).

Table 1: Demographic data.

Variable	Category	Frequency (N)	%
Gender	Male	52	52.7
	Female	58	47.3
Age (years)	Mean±SD	29.05±3.61	
Qualification	MBBS	76	69.1
	MD	34	30.9
Years of experience post-MBBS	<1	4	3.6
	1	14	12.7
	2–5	76	69.1
	6–10	16	14.5
Department	General medicine	20	18.2
	Casualty	4	3.6
	Anaesthesiology	4	3.6
	Pharmacology	14	12.8
	Community medicine	9	8.2
	Ophthalmology	6	5.5
	ENT	7	6.4
	Orthopaedics	5	4.5
	General surgery	5	4.5
	Dermatology	4	3.6
	Pediatrics	2	1.8
	Others	30	27.3

Post-MBBS experience varied, with most participants having 2–5 years of experience (76, 69.1%), followed by 6–10 years (16, 14.5%) and 1 year (14, 12.7%). Only 4 (3.6%) reported less than 1 year of experience. Departments represented included general medicine (20), pharmacology (14), community medicine (9), ENT (7), ophthalmology (6), anesthesiology (4), dermatology (4), pediatrics (2), orthopedics (5), general surgery (5), casualty medical officers (4), other specialties (30).

Knowledge of pharmacogenomic testing

Most respondents had previously heard the term 'pharmacogenomic testing' (n=96, 87.3%). Self-rated knowledge levels varied, with 38 participants (34.5%) rating themselves as fair, another 38 (34.5%) as average and 30 (27.3%) as poor. Only 4 (3.6%) rated themselves as good, none rated themselves excellent. Sources of information included textbooks (n=60, 54.5%), internet resources (n=36, 32.7%), colleagues (n=18, 16.4%), journals (n=16, 14.5%), and workshops (n=4, 3.6%). 14 respondents (12.7%) indicated no prior exposure to pharmacogenomics (Figure 1 and Table 2).

Awareness of pharmacogenomic guidelines/databases was limited. For CPIC, 76 (69.09%) rated their knowledge as poor and 24 (21.82%) as fair. PharmGKB knowledge was similarly limited, with 68 (61.82%) selecting poor and 32 (29.09%) fair. For ClinGen, 72 (65.45%) rated poor and 22 (20%) fair. Domestic guidelines were poorly known by 76 (69.09%), while 22 (20%) reported fair familiarity.

Regarding specific competencies, 82 (74.5%) reported knowing which drugs require testing, while 14 (12.7%) believed they could tailor therapy based on results. Only 8 (7.3%) believed they could recommend PGx testing, and 10 (9.1%) reported knowing available tests in their hospital. Two respondents (1.8%) described themselves as not familiar at all. Fourteen respondents (12.7%) were unable to list any medications for which pharmacogenomic testing is useful (Figure 2).

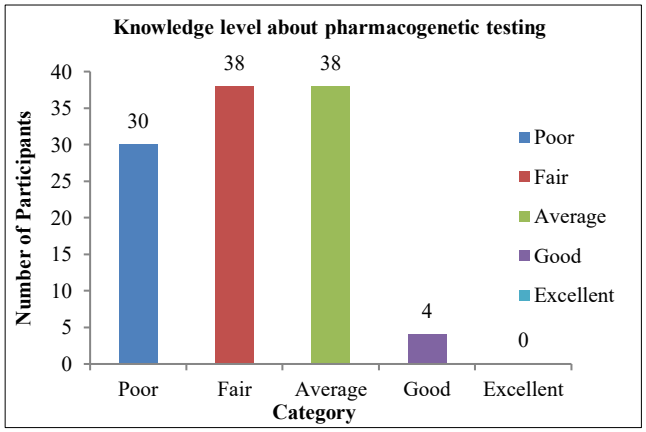

Figure 1: Knowledge level about pharmacogenetic testing.

Table 2: Source of information and number of participants data.

Source of information	Number of participants	Percentage (%)
Internet	36	32.7
Journals	16	14.5
Pharmacogenomics workshop	4	3.6
Colleagues	18	16.4
Textbooks	60	54.5
Not heard about it before	14	12.7

Attitudes toward pharmacogenomic testing

Forty respondents (36.4%) believed that all patients may benefit from pharmacogenomic testing, while 26 (23.6%) and 24 (21.8%) believed benefit lies primarily in predicting poor response and adverse reactions respectively. Only two respondents (1.8%) believed that testing is not beneficial.

44 (40%) participants agreed that pharmacogenomic testing can help explain drug reactions, and 44 (40%) participants agreed it can help identify drug interactions. Over half of respondents (56, 50.9%) agreed that pharmacogenomics can optimize drug choice and dosing.

Similarly, 62 (56.3%) agreed that PGx testing may improve efficacy and reduce adverse drug reactions. Forty-six (41.8%) believed it could help reduce pharmacotherapeutic costs (Figure 3).

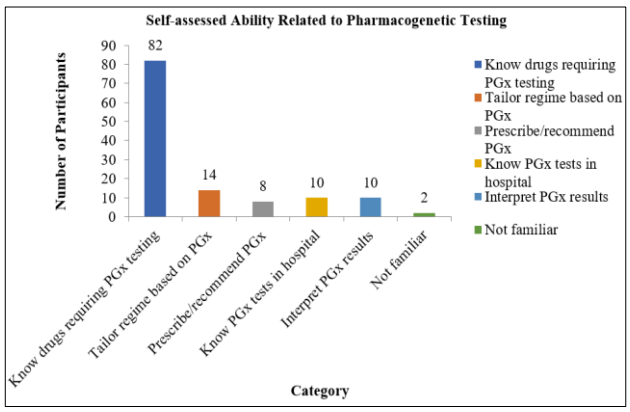

Figure 2: Self-assessed ability related to pharmacogenetic testing.

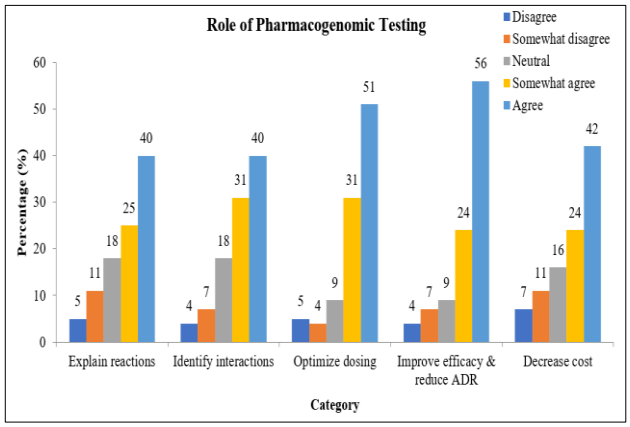

Figure 3: Attitude towards role of pharmacogenomic testing.

Importance was divided equally between improving efficacy (n=48, 43.6%) and reducing adverse reactions (n=48, 43.6%), with 14 (12.7%) uncertain. Twenty (18.2%) stated they were highly likely to recommend pharmacogenomic testing in future, and 44 (40%) stated they were generally likely (Figure 4).

Regarding the likelihood of recommending or prescribing pharmacogenomic testing in future clinical practice, the largest proportion of respondents reported that they considered it generally possible (44 respondents, 40 percent). This was followed by those who were uncertain about recommending such testing (32 respondents, 29.1 percent). A smaller proportion indicated high likelihood of recommending pharmacogenomic testing (20 respondents, 18.2 percent). Conversely, relatively few participants expressed negative expectations, with 8 respondents (7.3 percent) stating it was generally impossible and 6 respondents (5.5 percent) indicating it was entirely impossible.

In response to whether clinicians would be more likely to choose an alternative non-genetic test, such as a routine biochemical test, instead of pharmacogenomic testing when such a nongenetic test is available to predict or assess drug efficacy or safety, nearly half of the respondents indicated a preference for the non-genetic option (54 respondents, 49.1 percent). In contrast, 20 respondents (18.2 percent) reported that they would not prefer a nongenetic test over pharmacogenomic testing. A considerable proportion remained uncertain about their choice (36 respondents, 32.7 percent).

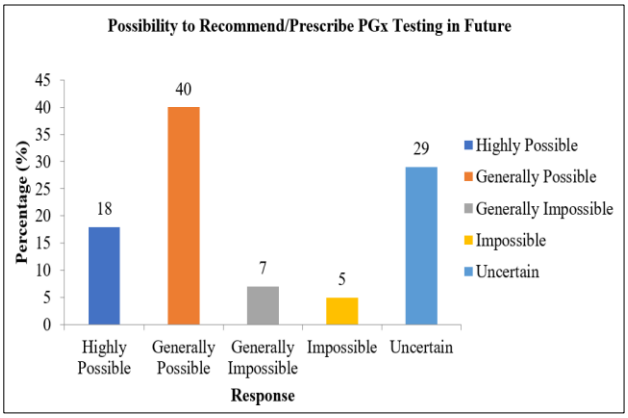

Figure 4: Possibility to recommend/prescribe PGx testing in future.

Practice of pharmacogenomic testing

Only 14 (12.7%) reported that their institution currently offers pharmacogenomic testing, while 44 (40%) reported that it does not and 52 (47.3%) were unaware. Twenty (18.2%) reported that their institution sends samples outside for testing, while 56 (50.9%) did not know.

Discussion of pharmacogenomic implications with patients was uncommon, with 46 (41.8%) reporting they never discuss these issues, and 26 (23.6%) reporting rarely. Only 8 respondents (7.3%) reported always discussing (Figure 5).

Pgx-related prescriptions were rare, with 90 respondents (81.8%) never having recommended testing. Ten (9.1%) had recommended testing to patients, eight (7.3%) to relatives, and four (3.6%) to colleagues (Figure 6).

Regarding clinical application, 60 (54.5%) would alter drug selection and 40 (36.4%) would alter dose if results affected efficacy; similarly, 42 (38.2%) would change drug option and 36 (32.7%) would modify dose if adverse reactions were relevant.

Collaboration with specialists was reported as rare by 34 (30.9%) and never by 64 (58.2%). Most respondents (n=62, 56.4%) had not discussed pharmacogenomics with patients and therefore could not assess receptivity.

With respect to patient receptiveness toward pharmacogenomic testing, more than half of the respondents reported that the question was not applicable, as they had not discussed pharmacogenomic testing with their patients (62 respondents, 56.4 percent). Among those who had engaged patients in discussions, 24 respondents (21.8 percent) perceived their patients as not receptive, while 16 respondents (14.5 percent) found them somewhat receptive. Only 8 respondents (7.3 percent) reported that patients were very receptive to pharmacogenomic testing.

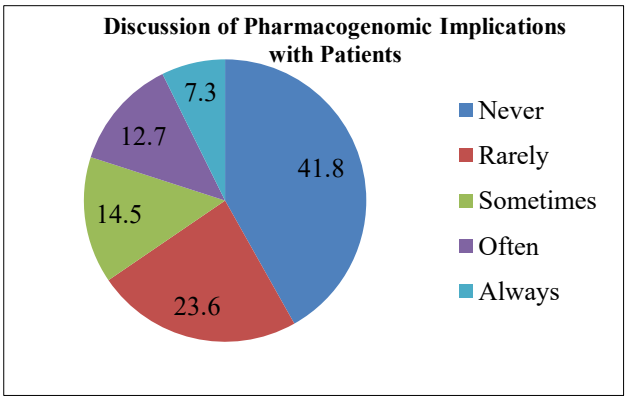

Figure 5: Discussion of pharmacogenomic implications with patients.

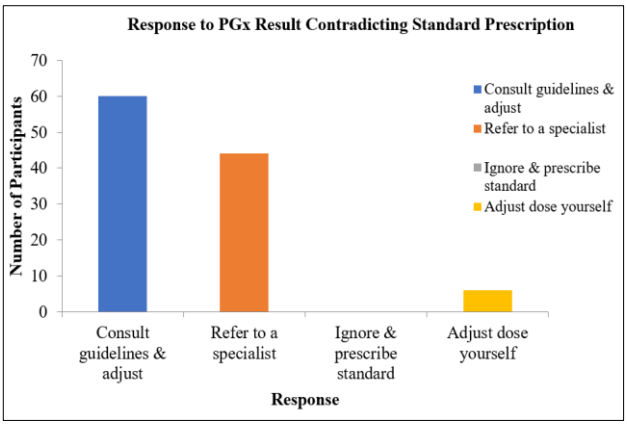

Figure 6: Response to PGx result contradicting standard prescription.

When faced with a result that contradicted standard prescribing practice, 60 (54.5%) would consult guidelines and adjust therapy, and 44 (40%) would refer to a specialist. None indicated they would ignore test results.

DISCUSSION

In our study most physicians (96/110; 87.3%) reported they had heard of pharmacogenomic (PGx) testing, and self-rated knowledge was concentrated in the lower tiers (poor 27.3%, fair 34.5%, average 34.5%), with only 3.6% reporting "good." This pattern, high awareness but low depth of knowledge, mirrors several prior KAP surveys.

Jia et al similarly found that a majority of physicians had heard of PGx (275/366; 75.1%) but most rated their knowledge as "fair" rather than "good/excellent," and only 20% selected "good/excellent".[21] Nawaz et al reported a somewhat lower level of perceived knowledge among healthcare providers in Punjab, with study respondents classified as having fair knowledge overall (approximately 58% acknowledging the importance of PGx and 74% correctly identifying core concepts).[22] Indian KAP studies show the same theme of awareness outstripping practical knowledge. Sharanya Shre et al reported a "vague understanding" among Chennai physicians despite interest in learning more, with fewer than half showing affirmative knowledge responses.[23]

Arathy et al found only ~38% reported being "somewhat familiar," with 40% expressing confidence in their understanding of genetics' influence on therapy, again, indicating modest depth despite reasonable familiarity.[24] Muflih et al (Jordan) reported perceived knowledge distribution leaning toward "fair/good" but actual knowledge scores were modest, consistent with overestimation of knowledge in self-report.[25]

Taken together, our results align with an international pattern: awareness of PGx is common, but substantive working knowledge is limited. Compared with Jia et al. and Naeem Nawaz et al, our cohort had slightly higher raw awareness (87.3% versus 75.1% and ~58% respectively), but the self-assessed depth of knowledge remains low, indicating that simply "having heard of PGx" does not equate to readiness to act on PGx results.[21]

Respondents in our study hold largely positive attitudes: most agree PGx can improve efficacy and reduce adverse reactions (62/110; 56.3% agree) and many think it can help optimize drug dosing (56/110; 50.9%). Similarly, Jia et al reported positive attitudes and strong confidence scores despite limited knowledge.[21] Muflih et al also found generally favourable attitudes even where objective knowledge was only adequate.[25] Shre et al noted enthusiasm and willingness to learn more despite knowledge gaps, and Arathy et al reported strong perceived usefulness of PGx information in drug labelling (94% found labelling helpful).[23,24] Thus, attitudes are consistently optimistic, physicians tend to accept the potential clinical value of PGx even when they lack deep practical experience. Our sample's split on whether PGx effects on efficacy or adverse reactions matter more (both 43.6%) echoes this balanced optimism.

Actual use of PGx testing remains low in our sample: physicians reported rarely or never discussing PGx with patients (Rarely 23.6%; Never 41.8%). Only 10 clinicians (9.1%) had recommended PGx testing to patients. These practice rates are consistent with Arathy et al who reported only 2% of respondents had ordered a PGx test in the previous year. By contrast, Jia et al reported a much higher proportion reporting prior ordering experience (154/366; 56.0% had ordered PGx tests at least once), and many Chinese physicians reported ordering 1–10 tests per year among those with experience.[21,24] Nawaz et al found mixed practice between pharmacists and physicians and overall moderate interest in implementation but limited routine ordering.[22] This suggests geographic and system-level variability: in China (Jia et al) PGx ordering activity appears more established than in our setting and then in the smaller Indian studies (Sharanya Shre, Arathy). System factors (availability of tests in hospitals, established clinical pathways, presence of clinical pharmacists) likely explain these differences.

Respondents in our study showed knowledge gaps, lack of testing facilities, and uncertainty about clinical value and costs. When faced with PGx results that contradict standard prescriptions, most would consult guidelines or refer to specialists (Consult guidelines 54.5%, Refer 40%). These barriers and responses reflect those described by Jia et al (lack of professionals, lack of hospital testing services, high cost), Muflih et al (concerns about confidentiality and expertise), and Nawaz et al (logistical and knowledge-related challenges).[21,22,25] Arathy et al similarly reported "not knowing what test to order" as the leading reason for not ordering tests. Across the five comparative studies and our dataset, the recurrent themes are clear: physicians are receptive to PGx, practical knowledge and ordering experience lag, and system supports (lab availability, guidelines, clinical pharmacists and training) are decisive enablers. Jia et al and Nawaz et al both suggest that increasing accessible, guideline-linked education and integrating clinical pharmacists could accelerate adoption; our respondents' preference for consulting guidelines and their readiness to adjust regimens if evidence supports it aligns with that approach.[21,22] When comparing across studies note differences in sample size, sampling frame, and respondent mix (e.g., Jia et al sampled 366 Chinese physicians recruited online across many provinces, Naeem Nawaz et al included physicians and pharmacists in Punjab, Pakistan with N=220, Muflih et al surveyed hospital clinicians in Jordan with N=200, and the Indian KAP studies had smaller samples and local focus). These methodological differences limit direct percentage-to-percentage comparability and likely drive some variability in reported practice rates.[21,22,25]

The limitations of the study are that it was conducted at a single institution, Mysore Medical College and Research Institute, which may limit the generalizability of the findings to other healthcare settings, as knowledge, attitudes, and practices regarding pharmacogenomics can vary depending on institutional infrastructure, training opportunities, and clinical exposure. Additionally, participants were recruited using a convenience sampling method, which may have introduced selection bias because doctors with greater interest in pharmacogenomics or higher engagement in departmental communication platforms may have been more likely to participate. Furthermore, the cross-sectional design and lack of longitudinal follow-up prevented assessment of whether educational interventions or institutional measures could

improve pharmacogenomic awareness and clinical practice over time. In addition, although 110 participants completed the survey, the sample size may still be insufficient to detect subtle differences between subgroups such as specialty, years of experience, or qualification level.

Improvement in the knowledge, attitude, and practice of pharmacogenomics among doctors requires integration of pharmacogenomics into undergraduate and postgraduate medical education, along with regular continuing medical education programs, workshops, and practical clinical training. Increased awareness of pharmacogenomic guidelines and resources such as clinical pharmacogenetics implementation consortium, PharmGKB, and ClinGen, combined with institutional support, multidisciplinary collaboration, development of national guidelines, research exposure, patient awareness initiatives, and digital learning platforms, may help improve pharmacogenomic competency and promote its implementation in clinical practice among doctors.

CONCLUSION

In conclusion, this study demonstrated that although most doctors at Mysore Medical College and Research Institute had heard of pharmacogenomic testing and generally expressed positive attitudes toward its potential clinical benefits, substantial gaps persisted in practical knowledge, awareness of established pharmacogenomic resources and guidelines and real-world clinical application. Participants recognized the potential of pharmacogenomics to optimize drug therapy, improve efficacy, and reduce adverse drug reactions, yet routine implementation and patient discussion remained uncommon. Limited familiarity with international pharmacogenomic databases and low confidence in interpreting or recommending testing suggest that current exposure among clinicians is largely theoretical rather than practice oriented. The findings further indicate that uncertainty regarding institutional infrastructure, limited interdisciplinary collaboration, and preference for conventional non-genetic testing approaches may represent important barriers to wider adoption. By systematically evaluating knowledge, attitudes, and practices across multiple specialties within a tertiary care teaching institution, this study contributes important baseline evidence regarding the current status of pharmacogenomic preparedness among Indian clinicians. The study advances understanding in the field by identifying specific educational, institutional, and implementation gaps that must be addressed to facilitate the integration of pharmacogenomics into routine clinical care, thereby supporting future curriculum development, policy planning, and targeted capacity building initiatives in precision medicine.

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