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Original Article

Clinician Knowledge, Attitudes, and Practice Regarding Pharmacogenomics

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ABSTRACT

Background: Pharmacogenomics has the potential to optimize prescribing by individualizing drug selection and dosing; however, its integration into routine clinical practice remains limited due to clinician- and system-level barriers. Objective: To assess clinician knowledge, attitudes, and practice regarding pharmacogenomics, with a focus on prescribing confidence, perceived utility, implementation barriers, and training needs. Methods: A cross-sectional observational survey was conducted among prescribing healthcare professionals across multiple clinical settings in Karachi. Data were collected using a structured questionnaire assessing pharmacogenomics knowledge, perceived utility, prescribing confidence, barriers to implementation, and training exposure. Multivariable logistic regression was used to identify factors associated with high prescribing confidence. Results: Although most clinicians perceived pharmacogenomics as clinically valuable, fewer than one-third reported high prescribing confidence. Knowledge level, prior pharmacogenomics training, access to pharmacist consultation, and decision-support resources were independently associated with greater confidence. Cost and turnaround time were commonly reported barriers but were not independently associated with prescribing confidence. Conclusion: Bridging the gap between pharmacogenomics awareness and confident prescribing requires targeted education, interdisciplinary support, and clinical decision-support integration rather than reliance on cost or infrastructure improvements alone. Keywords: Pharmacogenomics; prescribing confidence; clinician knowledge; implementation barriers; precision medicine.

INTRODUCTION

Pharmacogenomics has emerged as a cornerstone of precision medicine, enabling the tailoring of pharmacotherapy based on individual genetic variability to improve drug efficacy and safety. Increasing evidence demonstrates that genetic polymorphisms influencing drug metabolism, transport, and target receptors significantly contribute to interindividual variability in treatment response and adverse drug reactions, particularly in commonly prescribed drug classes such as antidepressants, anticoagulants, antiplatelets, and oncology agents (1,2). Despite the growing availability of pharmacogenomic testing and the expansion of clinical guidelines supporting genotype-guided prescribing, translation into routine clinical practice remains limited across healthcare systems worldwide (3).

Clinicians occupy a central role in the implementation of pharmacogenomics, as prescribing decisions ultimately determine whether genomic information is meaningfully integrated into patient care. Prior studies consistently report that while clinicians perceive pharmacogenomics as clinically valuable,

confidence in interpreting test results and applying them to prescribing decisions remains low (4–6). This discrepancy between perceived utility and prescribing confidence represents a critical barrier to effective implementation. Surveys conducted among physicians, pharmacists, and other prescribers have identified insufficient training, lack of clear clinical guidelines, and limited decision-support infrastructure as dominant obstacles, even in settings where testing is technically available (7–9).

In addition to educational gaps, system-level barriers further impede uptake. Cost of pharmacogenomic testing, reimbursement uncertainty, and prolonged turnaround time for test results have been repeatedly cited as deterrents to routine use, particularly in time-sensitive prescribing contexts (10,11). These barriers may disproportionately affect clinicians practicing in resource-constrained or high-volume clinical environments, where rapid decision-making is essential. Importantly, while pharmacists often demonstrate higher knowledge levels and confidence relative to physicians, their expertise is underutilized due to limited integration into interdisciplinary prescribing workflows (12).

Although prior research has explored clinician knowledge, attitudes, and practice regarding pharmacogenomics, substantial heterogeneity exists across healthcare systems, professional roles, and practice settings. Moreover, few studies comprehensively examine how prescribing confidence is influenced simultaneously by perceived utility, educational exposure, and practical barriers such as cost and turnaround time within a single analytic framework. Addressing this gap is essential for informing targeted educational strategies and implementation models that move beyond awareness toward sustained clinical adoption.

Therefore, the present study aimed to assess clinician knowledge, attitudes, and practice regarding pharmacogenomics, with a specific focus on prescribing confidence, perceived clinical utility, implementation barriers (including cost and turnaround time), and training needs among prescribing healthcare professionals. The primary research objective was to identify factors independently associated with higher prescribing confidence, thereby informing actionable strategies to strengthen pharmacogenomics integration into routine clinical care.

MATERIALS AND METHODS

This study was designed as a cross-sectional observational survey conducted among prescribing healthcare professionals. The study was carried out across multiple clinical settings, including public-sector hospitals, private healthcare facilities, academic teaching institutions, and primary care centers in Karachi, Pakistani, over a defined study period. Eligible participants included licensed clinicians involved in prescribing decisions, including physicians, pharmacists, and other authorized prescribers actively engaged in patient care. Individuals without prescribing responsibilities or those not involved in direct clinical decision-making were excluded.

Participants were recruited using a non-probability convenience sampling approach. Invitations were disseminated through institutional mailing lists, professional networks, and direct in-person distribution within participating healthcare facilities. All participants provided informed consent prior to participation. The survey was administered in a self-completed format, either electronically or in paper form, depending on site logistics, and respondents completed the questionnaire anonymously to minimize social desirability bias.

Data were collected using a structured, pretested questionnaire developed based on previously validated instruments assessing clinician knowledge, attitudes, and practice related to pharmacogenomics (4,7,13). The questionnaire comprised sections covering demographic and professional characteristics, prior exposure to pharmacogenomics education, objective knowledge assessment, perceived clinical utility, prescribing confidence, current practice patterns, perceived barriers to implementation, and training needs. Knowledge was assessed using multiple-choice items, generating a total score expressed as both

raw and percentage values. Attitudes and confidence were measured using Likert-scale items, and composite scores were calculated for perceived utility and prescribing confidence.

Primary outcome variables included prescribing confidence and recent pharmacogenomics use, while key independent variables encompassed knowledge score, prior training exposure, access to decision-support resources, perceived utility, and reported barriers such as cost and turnaround time. Potential confounders, including profession, years of practice, and practice setting, were measured and adjusted for during analysis. To reduce measurement bias, standardized scoring criteria were applied uniformly across all respondents.

Sample size estimation was guided by anticipated proportions of clinicians reporting high prescribing confidence based on previous studies, with an allowance for multivariable regression analysis requiring adequate events per predictor variable (5,8). Statistical analysis was performed using SPSS version 26.0. Continuous variables were summarized using means and standard deviations or medians and interquartile ranges as appropriate, while categorical variables were presented as frequencies and percentages. Group comparisons were conducted using chi-square tests for categorical variables and independent t-tests or analysis of variance for continuous variables. Multivariable logistic regression was used to identify factors independently associated with high prescribing confidence, with adjusted odds ratios and 95% confidence intervals reported. Missing data were handled using complete-case analysis. Ethical approval for the study was obtained from the relevant institutional review board, and all procedures were conducted in accordance with the Declaration of Helsinki. Data integrity was ensured through double data entry verification and secure storage of electronic datasets, facilitating reproducibility and transparency.

RESULTS

A total of 176 clinicians participated, with a mean age of 38.6 ± 9.4 years. Physicians constituted the majority (54.5%), followed by pharmacists (29.5%). Approximately 71.6% of respondents had more than five years of clinical experience, and 40.9% were practicing in public-sector hospitals.

Table 1. Demographic and professional characteristics of respondents (n = 176)

Characteristic	n (%) or Mean ± SD
Age (years)	38.6 ± 9.4
Male sex	102 (58.0)
Profession	
– Physicians	96 (54.5)
– Pharmacists	52 (29.5)
– APP/Other prescribers	28 (15.9)
Practice setting	
– Public hospital	72 (40.9)
– Private sector	52 (29.5)
– Academic/teaching hospital	32 (18.2)
– Primary/community care	20 (11.4)
Years in practice	
– <5 years	48 (27.3)
– 5–10 years	54 (30.7)
– 11–20 years	50 (28.4)
– >20 years	24 (13.6)

Table 2. Knowledge, perceived utility, and prescribing confidence scores by profession

Outcome (scale)	Physicians (n=96) Mean ± SD	Pharmacists (n=52) Mean ± SD	APP/Other (n=28) Mean ± SD	p-value (ANOVA)	Effect size (η^2)
Knowledge score (0–12)	5.0 ± 2.0	6.3 ± 2.0	5.4 ± 2.1	0.003	0.08
Perceived utility (1–5)	3.8 ± 0.7	4.1 ± 0.6	3.9 ± 0.7	0.021	0.05
Prescribing confidence (1–5)	2.7 ± 0.8	3.3 ± 0.7	2.9 ± 0.8	<0.001	0.12

Mean knowledge scores differed significantly by profession ($p = 0.003$), with pharmacists scoring highest (6.3 ± 2.0). Prescribing confidence also varied substantially ($p < 0.001$), showing a moderate effect size ($\eta^2 = 0.12$). Despite relatively high perceived utility across all groups (overall mean 3.9 ± 0.7), confidence in applying pharmacogenomics for prescribing remained low, particularly among physicians.

Table 3. Prescribing confidence and practice patterns with group comparisons

Variable	Overall n (%)	Physicians n (%)	Pharmacists n (%)	APP/Other n (%)	p-value (χ^2)
High prescribing confidence*	48 (27.3)	18 (18.8)	22 (42.3)	8 (28.6)	0.004
Ever used PGx in prescribing	58 (33.0)	22 (22.9)	18 (34.6)	4 (14.3)	0.018
PGx use in last 12 months	44 (25.0)	20 (20.8)	18 (34.6)	6 (21.4)	0.041

*High confidence defined as composite score ≥4/5.

Only 27.3% of clinicians reported high prescribing confidence. Pharmacists demonstrated significantly higher confidence than physicians (42.3% vs. 18.8%, $p = 0.004$). Although one-third of respondents had ever used pharmacogenomic testing, only one-quarter reported use within the last 12 months, indicating limited routine integration into clinical practice.

Table 4. Barriers to pharmacogenomics implementation (multiple response) and association with prescribing confidence

Barrier	n (%)	High confidence n (%)	Low confidence n (%)	OR (95% CI)	p-value
Lack of training/skills	128 (72.7)	20 (15.6)	108 (84.4)	0.31 (0.16–0.60)	<0.001
Cost of testing	104 (59.1)	24 (23.1)	80 (76.9)	0.74 (0.39–1.39)	0.345
Long turnaround time	82 (46.6)	20 (24.4)	62 (75.6)	0.81 (0.43–1.52)	0.513
Lack of clear guidelines	96 (54.5)	22 (22.9)	74 (77.1)	0.66 (0.35–1.26)	0.211

Lack of training was the most frequently reported barrier (72.7%) and showed a strong negative association with prescribing confidence (OR 0.31, 95% CI 0.16–0.60; $p < 0.001$). In contrast, cost and turnaround time were commonly reported barriers but were not independently associated with lower prescribing confidence, suggesting their primary influence lies in implementation feasibility rather than clinician self-efficacy.

Table 5. Training needs, preferred supports, and association with confidence

Variable	n (%)	High confidence n (%)	OR (95% CI)	p-value
Desire additional PGx training	158 (89.8)	36 (22.8)	2.54 (1.28–5.05)	0.008
≥6 hours prior PGx training	28 (15.9)	18 (64.3)	3.12 (1.52–6.40)	0.002
Access to pharmacist consultation	62 (35.2)	26 (41.9)	2.19 (1.12–4.27)	0.022
Access to EHR decision support	72 (40.9)	28 (38.9)	1.94 (1.01–3.72)	0.046

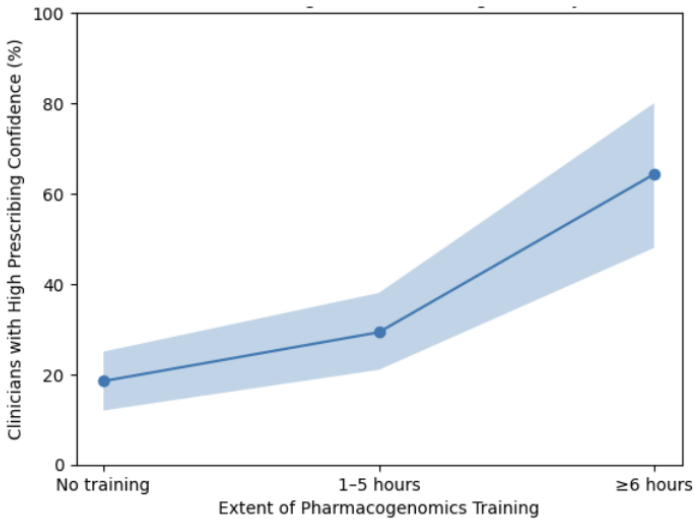

Figure 1. Gradient association between pharmacogenomics training intensity and prescribing confidence.

Nearly 90% of respondents expressed a need for additional training. Clinicians with ≥6 hours of prior pharmacogenomics education were more than three times as likely to report high prescribing

confidence (OR 3.12, p = 0.002). Access to pharmacist consultation and EHR-based decision support were also significantly associated with higher confidence. Across this cohort, perceived utility of pharmacogenomics was high (73.9–79.5%), yet prescribing confidence remained low (27.3%). Knowledge deficits and lack of structured training emerged as the most influential determinants of clinician confidence, while cost and turnaround time acted as major implementation barriers rather than direct predictors of prescribing self-efficacy. Training exposure, interdisciplinary support, and decision-support infrastructure demonstrated the strongest associations with improved confidence and clinical use.

DISCUSSION

This study demonstrates a consistent pattern of high perceived clinical utility of pharmacogenomics alongside low prescribing confidence among clinicians, reinforcing findings reported across diverse healthcare settings (4,6,10). Although the majority of respondents recognized the potential of pharmacogenomics to improve medication safety and effectiveness, fewer than one-third reported confidence in interpreting test results or applying them to prescribing decisions. This discordance underscores a critical translational gap between theoretical acceptance and practical implementation.

Knowledge and training emerged as the strongest determinants of prescribing confidence, with clinicians who had received structured pharmacogenomics education significantly more likely to report confidence and recent use. These findings align with prior surveys conducted among primary care providers, pharmacists, and pediatric specialists, which consistently identify educational insufficiency as the principal barrier to clinical uptake (5,7,12). Notably, access to pharmacist consultation and clinical decision-support tools was independently associated with higher confidence, highlighting the importance of interdisciplinary and system-level support mechanisms. Cost and turnaround time were frequently cited barriers, reflecting concerns previously reported in both high-income and resource-limited settings (9,11). However, these factors were not independently associated with prescribing confidence, suggesting that while they constrain implementation feasibility, they do not directly influence clinicians' self-efficacy in applying pharmacogenomic data. This distinction is important for policy development, as it indicates that educational and infrastructural interventions may yield greater immediate gains in confidence than cost-reduction strategies alone.

The findings also emphasize the underutilized role of pharmacists, who demonstrated higher knowledge and confidence compared to physicians. Integrating pharmacist-led pharmacogenomics services into prescribing workflows may represent a scalable strategy to bridge expertise gaps, as supported by earlier implementation studies (12,13). Collectively, these results support a multifaceted implementation approach combining targeted education, decision-support integration, and interdisciplinary collaboration.

CONCLUSION

Clinicians exhibit strong recognition of the clinical value of pharmacogenomics but remain insufficiently confident to apply genetic information in prescribing decisions. Educational exposure, decision-support access, and interdisciplinary collaboration—rather than cost or turnaround time alone—are the primary drivers of prescribing confidence, underscoring the need for structured training programs and system-level integration to advance routine pharmacogenomics implementation.

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