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Original Article

Physician Readiness for Pharmacogenomics and Genomic-Guided Prescribing: A Cross-Sectional Study at Government College University, Faisalabad, Pakistan

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ABSTRACT

Background: Pharmacogenomics (PGx) enables genotype-guided prescribing to improve drug safety and efficacy; however, implementation in low- and middle-income countries remains limited. Physician readiness—encompassing knowledge, attitudes, competence, practice behavior, and perceived barriers—is critical for clinical integration. Objective: To evaluate PGx knowledge, attitudes, self-efficacy, practice patterns, barriers, and predictors of readiness among physicians affiliated with Government College University (GCU), Faisalabad, Pakistan. Methods: A cross-sectional survey of 137 physicians was conducted using a structured instrument assessing objective knowledge (0–15), attitudes (1–5), self-efficacy (1–5), practice index (0–6), barrier score (1–5), and composite readiness (0–100). "Ready" was defined as ≥65. Associations were examined using t-tests, chi-square tests, and multivariable logistic regression with adjusted odds ratios (OR) and 95% confidence intervals (CI). Results: Mean readiness was 61.2±12.8, with 32.1% classified as ready. Formal PGx training (23.4% prevalence) was associated with higher knowledge (10.8±2.0 vs 8.1±2.3; p<0.001; g=1.20) and readiness (72.0±10.0 vs 58.0±12.0; p<0.001). Training independently predicted readiness (OR=3.6; 95% CI 1.5–8.7; p=0.004), as did knowledge of local ordering pathways (OR=4.2; 95% CI 1.8–10.0; p=0.001), while higher barrier scores reduced readiness (OR=0.55 per unit increase; p=0.009). Conclusion: Physician readiness for PGx at GCU Faisalabad is moderate but suboptimal; structured education and system-level infrastructure are essential to translate favorable attitudes into genomic-guided prescribing. Keywords: shared decision-making; decision aids; cardiovascular risk; primary prevention; randomized controlled trial

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INTRODUCTION

Pharmacogenomics (PGx) examines how inherited genetic variability influences drug disposition and pharmacodynamic response, enabling individualized selection and dosing intended to maximize benefit while reducing harm (1). Clinically actionable variants in drug-metabolizing enzymes and transporters—most prominently CYP2D6, CYP2C19, and TPMT—have been repeatedly linked to meaningful differences in therapeutic response and adverse drug reaction (ADR) risk across psychiatry, cardiology, infectious diseases, and oncology (2,3). As precision medicine has expanded from a conceptual agenda to a clinical imperative, the "right drug, right dose, right patient" paradigm has increasingly shaped modern prescribing expectations and health-system priorities (4).

ADRs remain a major contributor to avoidable morbidity and healthcare utilization. Large observational evidence indicates that medication-related harm is a frequent cause of hospitalization and may be preventable when high-risk prescribing is anticipated and mitigated (5). In response, genomic-guided prescribing has been operationalized through implementation models that integrate testing, interpretation, and decision support, with multiple programs reporting improved medication safety and more predictable therapeutic response when genotype information is incorporated into prescribing workflows (6,7). To translate evidence into practice, standardized guidance has also emerged through internationally recognized PGx knowledgebases and clinical guideline consortia that provide genotype-to-therapy recommendations and support harmonized clinical application (8).

Despite the maturation of evidence and guidance, real-world integration of PGx into routine clinical practice remains uneven, particularly in low- and middle-income countries where constrained resources, limited laboratory capacity, cost barriers, and fragmented test-ordering pathways can impede adoption even when physician attitudes are favorable (9–11). In this context, physician readiness becomes a decisive implementation determinant because it captures not only awareness and factual knowledge but also perceived competence, perceived feasibility, and the degree to which clinicians can translate favorable beliefs into measurable prescribing behaviors within available systems (12). Readiness is therefore best conceptualized as a multidimensional construct spanning objective knowledge, attitudes, self-efficacy, prior practice exposure, and perceived barriers that collectively shape the likelihood of sustained uptake at the point of care (12).

Within Pakistan, genomic medicine is developing, but the clinical infrastructure and routine pathways that enable PGx-guided prescribing are still emerging. Consequently, physicians may endorse PGx in principle while lacking the practical competence and system knowledge needed to order tests, interpret results, and act on guidance during time-pressured clinical decision-making. Empirical readiness data from Pakistani academic clinical environments remain limited, creating a local evidence gap that restricts targeted curriculum design, continuing medical education planning, and institutional pathway development. Accordingly, this study evaluated physicians affiliated with Government College University (GCU), Faisalabad, to quantify PGx-related knowledge, attitudes, self-efficacy, current practice behaviors, perceived barriers, and a composite readiness score, and to identify independent predictors of being "ready" for genomic-guided prescribing within this setting (12).

MATERIALS AND METHODS

A cross-sectional analytical survey was conducted among physicians affiliated with Government College University (GCU), Faisalabad, Pakistan, between January and April 2026 to assess readiness for pharmacogenomics-guided prescribing within an academic clinical environment. Eligible participants included house officers, medical officers, residents, registrars, consultants, and general practitioners affiliated with GCU or associated clinical facilities, while physicians who were unavailable during the study period or who declined participation were excluded. A census-style approach was used to invite all eligible physicians accessible through departmental coordination and clinical rosters during the data-collection period, and participation was voluntary following written informed consent; the final analytical sample comprised 137 completed questionnaires, yielding a response rate exceeding 80%.

Data were collected using a structured, self-administered questionnaire developed with content mapping to previously used physician PGx readiness instruments and adoption literature, ensuring coverage of core readiness domains relevant to implementation in routine care (10,12). The instrument captured demographic and professional characteristics and measured: (i) objective PGx knowledge using 15 multiple-choice items scored 0–15; (ii) attitudes toward PGx using Likert-type items scored 1–5; (iii) self-efficacy/competency using Likert-type items scored 1–5; (iv) prior PGx-related practice exposure using a practice index scored 0–6; and (v) perceived barriers using Likert-type items scored 1–5 with higher scores indicating greater perceived obstacles. Formal PGx training was operationally defined a priori as at least 2 hours of structured education or training exposure in pharmacogenomics, consistent with an "actionable exposure" threshold intended to distinguish brief awareness from structured learning sufficient to influence competence and clinical behavior (10).

A composite readiness score (0–100) was computed by standardizing each domain score to a 0–100 metric and combining domains using equal weighting to preserve interpretability and prevent dominance of any single construct, reflecting the conceptual definition of readiness as multidimensional rather than knowledge-only (12). Readiness was dichotomized for inferential modeling, with "ready" defined as composite readiness ≥65/100 to represent a pragmatic threshold for implementation preparedness in which knowledge, competence, and feasibility collectively exceed a moderate benchmark. Primary independent variables included formal PGx training, objective knowledge score, awareness of local PGx ordering pathway, perceived barrier score, professional rank, years in practice, specialty grouping, and practice setting. The "ordering pathway knowledge" variable was treated as a practical system-readiness indicator aligned with test accessibility and implementation feasibility at the point of care, consistent with adoption barriers described in pharmacogenetics implementation research (11).

To reduce information bias, the questionnaire was administered anonymously without collection of personally identifying information, and standardized instructions were used to minimize interviewer effects. To mitigate confounding in estimating independent associations with readiness, multivariable logistic regression was prespecified with clinically plausible covariates entered simultaneously, and multicollinearity was assessed using variance inflation factors prior to model interpretation. Data integrity procedures included double-checking coded entries against questionnaire responses, restricting data access to the research team, and maintaining an audit trail of coding decisions in the analysis file. Statistical analyses were performed using SPSS version 26. Continuous variables were summarized as mean ± standard deviation and categorical variables as frequencies and percentages. Trained versus non-trained physicians were compared using independent-sample t-tests for continuous measures and chi-square tests for categorical associations, including the association between formal training and readiness classification; effect size for the chi-square association was quantified using Cramer's V. For readiness prediction, binary logistic regression was used to estimate adjusted odds ratios with 95% confidence intervals; model calibration was evaluated using goodness-of-fit testing and overall explanatory contribution was summarized using pseudo-R^2 indices. Missing data were handled using a complete-case approach for each analysis, with domain scores computed only when the required items were available to avoid imputing psychometric constructs. Statistical significance was set at $p<0.05$.

Ethical approval was obtained from the Institutional Review Committee of Government College University, Faisalabad, and written informed consent was obtained from all participants prior to enrollment. Study conduct followed recognized ethical principles for human participant research, including voluntary participation, confidentiality, and secure data handling (13,14).

RESULTS

Of 137 physicians, 23.4% (n=32) reported formal PGx training, while 76.6% (n=105) did not. Consultants constituted the largest professional group (41.6%), and most respondents were aged 31–40 years (40.1%), with 62.8% male representation.

Table 1. Demographic and Professional Characteristics (n = 137)

Variable	Category	n (%)
Gender	Male	86 (62.8)
	Female	51 (37.2)
Age group (years)	25–30	44 (32.1)
	31–40	55 (40.1)
	41–50	26 (19.0)
	>50	12 (8.8)
Years in practice	1–5	38 (27.7)
	6–10	41 (29.9)
	11–15	29 (21.2)
	>15	29 (21.2)
Professional rank	House officer / Medical Officer	34 (24.8)
	Registrar / Resident	46 (33.6)
	Consultant / Attending	57 (41.6)
Practice setting	Public	63 (46.0)
	Private	49 (35.8)
	Both	25 (18.2)
Specialty	Medicine & allied	53 (38.7)
	Surgery & allied	34 (24.8)
	Family medicine / GP	28 (20.4)

Variable	Category	n (%)
	Pediatrics	22 (16.1)
Formal PGx training (≥2 hours)	Yes	32 (23.4)
	No	105 (76.6)

Table 2. Pharmacogenomics Domains by Training Status With Effect Sizes and 95% CIs

Domain (Scale)	Trained (n=32) Mean±SD	Not trained (n=105) Mean±SD	Mean Difference (95% CI)	p-value	Effect size (Hedges g, 95% CI)
Objective knowledge (0–15)	10.8±2.0	8.1±2.3	2.70 (1.87 to 3.53)	<0.001	1.20 (0.78 to 1.62)
Attitude (1–5)	4.30±0.45	4.00±0.53	0.30 (0.11 to 0.49)	0.002	0.58 (0.18 to 0.98)
Self-efficacy (1–5)	3.90±0.55	3.20±0.69	0.70 (0.47 to 0.93)	<0.001	1.05 (0.64 to 1.47)
Practice index (0–6)	2.2±1.3	0.8±1.0	1.40 (0.91 to 1.89)	<0.001	1.29 (0.87 to 1.72)
Barrier score (1–5; higher = more barriers)	3.30±0.55	3.83±0.61	−0.53 (−0.76 -−0.30)	<0.001	−0.88 (−1.29 to −0.48)
Readiness total (0–100)	72.0±10.0	58.0±12.0	14.00 (9.80 to 18.20)	<0.001	1.20 (0.78 to 1.62)

Formal PGx training was associated with substantial, clinically meaningful differences across all readiness domains. Trained physicians had higher objective knowledge (+2.70 points, 95% CI 1.87–3.53) with a large standardized difference (g=1.20). The largest standardized contrasts were observed in practice behavior (g=1.29) and self-efficacy (g=1.05), indicating that training aligned more strongly with applied competence than with attitude alone (attitude difference 0.30, g=0.58). Trained physicians also reported lower perceived barriers by 0.53 units (95% CI −0.76 to −0.30), corresponding to a moderate-to-large reduction in barrier burden (g=−0.88). Overall readiness was 14.0 points higher among trained physicians (95% CI 9.80–18.20) with a large effect (g=1.20).

Table 3. Key Readiness Indicators (Item-Level Frequencies)

Indicator	Yes n (%)	No n (%)
Aware genetic variation can affect drug response	102 (74.5)	35 (25.5)
Familiar with the term "pharmacogenomics (PGx)"	95 (69.3)	42 (30.7)
Believes PGx improves safety / reduces ADRs	118 (86.1)	19 (13.9)
Believes PGx improves efficacy / "right drug, right dose"	121 (88.3)	16 (11.7)
Comfortable discussing PGx testing with patients	54 (39.4)	83 (60.6)
Knows where/how to order a PGx test (local pathway)	41 (29.9)	96 (70.1)
Ever ordered any genetic/PGx test in practice (past 12 months)	18 (13.1)	119 (86.9)
Ever changed drug/dose due to suspected genetic variability	27 (19.7)	110 (80.3)
Would use PGx routinely if affordable + available	112 (81.8)	25 (18.2)

Although belief in benefit was very high (86.1% for safety and 88.3% for efficacy), practical integration indicators were low: only 29.9% knew how to order PGx testing locally and only 13.1% had ordered any genetic/PGx test in the prior 12 months. The most prominent "implementation gap" appeared between willingness (81.8%) and operational capability (ordering pathway knowledge 29.9%), consistent with readiness being constrained by system-level feasibility rather than attitude.

Table 4. Readiness Classification and Association with Training

Formal PGx training	Ready n (%)	Not ready n (%)	Total
Yes (n=32)	18 (56.3)	14 (43.7)	32
No (n=105)	26 (24.8)	79 (75.2)	105
Total (n=137)	44 (32.1)	93 (67.9)	137
Association statistics		Value	
Chi-square (χ^2)		9.76	
p-value		0.0018	

Only 32.1% of physicians met the readiness threshold. Readiness prevalence was 56.3% among trained physicians versus 24.8% among untrained, reflecting an absolute difference of 31.5 percentage points. Training was associated with nearly 4-fold higher odds of readiness (OR=3.91, 95% CI 1.71–8.93) and more than double the probability of being ready (RR=2.27, 95% CI 1.45–3.57), with a small-to-moderate association by Cramer's V (0.27).

Table 5. Multivariable Predictors of "Ready" (Binary Logistic Regression)

Predictor	Adjusted OR	95% CI	p-value	log(OR)
Formal PGx training (Yes vs No)	3.6	1.5–8.7	0.004	1.28
Consultant rank (vs HO/MO)	1.9	0.9–4.1	0.090	0.64
Public setting (vs private/both)	0.8	0.4–1.6	0.520	−0.22
Knows ordering pathway (Yes vs No)	4.2	1.8–10.0	0.001	1.44
Barrier score (per +1 on 1–5 scale)	0.55	0.35–0.86	0.009	−0.60
Years in practice (per +5 years)	1.2	0.9–1.7	0.210	0.18

After adjustment, the strongest independent predictors of readiness were ordering pathway knowledge (OR=4.2) and formal PGx training (OR=3.6). Barrier burden demonstrated a significant inverse association, with each 1-point increase in barrier score corresponding to 45% lower odds of readiness (OR=0.55). Professional seniority indicators did not retain statistical significance after adjustment, suggesting that readiness is more strongly determined by actionable training and operational system knowledge than by rank or time in practice.

DISCUSSION

This study provides one of the first structured evaluations of physician readiness for pharmacogenomics-guided prescribing within a Pakistani academic clinical environment and demonstrates that although attitudinal acceptance is high, operational readiness remains limited. Only 32.1% of physicians met the predefined readiness threshold despite 86–88% endorsing the clinical value of PGx for safety and efficacy. This divergence between favorable perception and applied capability mirrors implementation research in genomic medicine showing that positive attitudes alone are insufficient for sustained clinical integration (9–12). The largest training-associated effects were observed in practice behavior (Hedges g=1.29) and self-efficacy (g=1.05), whereas attitude differences were comparatively smaller (g=0.58), suggesting that educational exposure primarily strengthens actionable competence rather than belief.

Formal PGx training independently increased readiness nearly fourfold (adjusted OR=3.6), while knowledge of local ordering pathways exerted an even stronger association (OR=4.2). These findings reinforce that readiness is not solely cognitive but also system-dependent. Implementation frameworks in precision medicine emphasize the interaction between provider capability and institutional infrastructure, including laboratory access, clinical decision support, and workflow integration (11,14). The present results indicate that physicians who understand how to operationalize PGx within their local system are substantially more prepared to integrate it into prescribing decisions, supporting the view that structural facilitation may be as critical as educational reform.

Barrier burden demonstrated a significant inverse relationship with readiness, with each one-point increase in perceived barriers reducing the odds of readiness by 45%. Cost, limited laboratory pathways, and absence of institutional support likely represent tangible obstacles in resource-constrained settings. Similar barrier gradients have been documented internationally, where implementation success correlates with reimbursement models, institutional endorsement, and embedded pharmacogenomics services (6,11). Importantly, consultant rank and years in practice were not statistically significant predictors after adjustment, suggesting that experiential seniority does not compensate for the absence of structured training or system knowledge. This finding aligns with prior work indicating that contemporary genomic competencies depend more on targeted education than on cumulative clinical exposure (12,13).

The implementation gap identified in this study is particularly notable: 81.8% reported willingness to use PGx if affordable and available, yet only 13.1% had ordered a test in the previous year. This discrepancy underscores a translational bottleneck between intention and execution. From a systems perspective, this suggests that curricular interventions alone may be insufficient unless accompanied by clear institutional pathways, laboratory linkages, and point-of-care decision support tools. In comparable settings, structured continuing medical education modules combined with clinical pharmacogenetics consultation services have demonstrated measurable improvements in test utilization and prescribing confidence (6,13).

Several limitations merit consideration. First, the single-center design limits generalizability to other Pakistani institutions or non-academic settings. Second, self-reported measures may overestimate knowledge or competence due to social desirability bias. Third, because training exposure was not randomized, reverse causality cannot be excluded; physicians with intrinsic interest in genomics may be more likely to pursue training, thereby inflating observed associations. Fourth, although composite readiness scoring was standardized and equally weighted across domains, external validation of the ≥65 threshold in other populations would strengthen interpretability. Despite these limitations, the study's strengths include use of multidimensional readiness assessment, effect-size reporting, multivariable modeling, and operational measurement of implementation-relevant constructs such as ordering pathway knowledge.

Collectively, the findings suggest that physician readiness for pharmacogenomics in this context is constrained less by attitudinal resistance and more by educational exposure and infrastructural accessibility. Targeted curriculum reform, accredited continuing education programs, and establishment of clear PGx ordering pathways may therefore represent high-yield interventions for accelerating genomic integration into routine prescribing practice in Pakistan.

CONCLUSION

Physician readiness for pharmacogenomics-guided prescribing at Government College University, Faisalabad is moderate but insufficient for widespread clinical implementation, with only one-third meeting the predefined readiness threshold. Formal training, awareness of local ordering pathways, and lower perceived barrier burden independently predict readiness, whereas seniority alone does not. Educational reform coupled with system-level infrastructure development is essential to translate high attitudinal acceptance into practical, sustained genomic-guided prescribing in resource-constrained academic settings.

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