Specialty Journal of Pharmacognosy, Phytochemistry, and Biotechnology
ISSN: 3062-441X
2025, Volume5, Page No: 150-160

Available online at: www.galaxypub.co/page/journals

Galaxy Publication

Assessing Awareness and Adoption of Pharmacogenomics Among Healthcare Professionals and Researchers in China

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Received: 23 April 2025; **Revised:** 01 August 2025; **Accepted:** 02 August 2025

ABSTRACT

To explore the domestic factors affecting the implementation of pharmacogenomics (PGx) and its future prospects in China, we carried out a questionnaire-based survey on PGx applications and testing. The survey was designed on the widely used online platform "Wenjuanxing" (www.wjx.cn) and distributed via the social media app WeChat. Among the 422 respondents, 27.7% were physicians, 31.3% were pharmacists, and 41.0% were researchers. Less than half of the physicians recognized the importance of PGx in drug therapy, whereas over half of the pharmacists and researchers acknowledged its significance. Only 38.5% of physicians, 40.9% of pharmacists, and 55.5% of researchers agreed that PGx testing could help reduce patients' economic burden. Nonetheless, the majority supported the effective integration of PGx into clinical practice. Key barriers to implementation included the absence of sector-specific standards, limited clinical research, and insufficient guidelines. Among drugs linked to PGx assays, warfarin and clopidogrel were the most frequently cited. Despite rapid advancements in PGx research in mainland China in recent years, its clinical application remains limited.

Keywords: Pharmacogenetics, Pharmacogenomics, Genomics, Survey, Clinical pharmacology

How to Cite This Article: Sousa D, Teixeira B, Ribeiro R, Rocha M. Assessing Awareness and Adoption of Pharmacogenomics Among Healthcare Professionals and Researchers in China. Spec J Pharmacogn Phytochem Biotechnol. 2025;5:150-60. https://doi.org/10.51847/yQQx6dEyqC

Introduction

Pharmacogenomics (PGx) plays a critical role in determining how individuals respond to medications, influencing both treatment effectiveness and the risk of adverse drug reactions [1–3]. Its rapid development has advanced precision medicine, allowing therapies to be tailored to individual genetic profiles [1]. Regulatory agencies such as the U.S. FDA recommend PGx testing for hundreds of medications [2], and databases like PharmGKB provide extensive annotations linking genes to drugs, pathways, and clinical guidance [3]. Numerous international organizations—including CPIC (U.S.), DPWG (Netherlands), CPNDS (Canada), and RNPGx (France)—have established clinical frameworks to guide PGx testing [4-7]. Hospitals such as Mayo Clinic, Mount Sinai, St. Jude Children's Hospital, Florida University College of Medicine, and Vanderbilt University Medical Center have adopted PGx-guided dosing into routine care [8].

In China, PGx research has made notable strides over the last decade. In 2011, the Chinese Pharmacological Society created a dedicated Division of Pharmacogenomics to focus on domestic PGx research and applications [9]. In 2015, the Ministry of Health issued interim guidelines standardizing PGx testing for drug-metabolizing enzymes and individualized anticancer therapies [10]. The National Medical Products Administration has approved around 200 PGx-related test kits [11]. Despite these advances, integration of PGx into routine clinical practice has been slow. Although more hospitals and biotech companies now offer PGx services, the total number of tests conducted annually remains limited [12]. Adoption depends not only on scientific progress but also on how effectively physicians interpret PGx results for patient care.

To better understand the barriers and opportunities for clinical PGx implementation in China, we designed a comprehensive questionnaire informed by previous studies [13-15]. Our survey targeted physicians, pharmacists,

and researchers to evaluate their knowledge, perceptions, and use of PGx, aiming to guide future strategies for broader implementation.

Materials and Methods

The survey included 20 questions across five sections. The first section (Q1–Q5) collected demographic information, including age, gender, educational background, profession, and geographic location. Questions Q6–Q10 focused on participants' understanding of PGx, including its role in drug selection, dosing, and predicting adverse events. Question Q11 examined perceived barriers to PGx adoption, while Q12–Q19 explored potential strategies to facilitate implementation. The final question (Q20) assessed the availability of PGx testing at participants' workplaces.

Response options for most questions included: "do not know," "disagree," "leaning disagree," "leaning agree," and "agree." The two intermediate options were added to capture subtle attitudes and prevent misclassification of responses. The survey was hosted on the "Wenjuanxing" online platform (www.wjx.cn) and distributed through WeChat between April and May 2019. Eligible participants were limited to physicians, pharmacists, and researchers, and participation was voluntary and anonymous. The study received ethical approval from the Institutional Review Board of the Third Xiangya Hospital of Central South University (AAHRPP-accredited).

Data analysis

Responses were summarized using percentages. Participants were stratified into physicians, pharmacists, and researchers for comparison. Questions with more than 50% agreement were considered positive responses, and less than 50% were negative. Group differences were analyzed using chi-square tests. Logistic regression was employed to control for potential confounding factors, with adjusted odds ratios (OR), 95% confidence intervals (CI), and p-values reported ($p < 0.05$ considered significant). Additionally, a word cloud approach was used to visualize the most frequently tested drugs across institutions [16].

Results and Discussion

Demographic characteristics of participants

Out of 918 survey respondents, 422 met the inclusion criteria based on their professional roles. These participants represented 25 provinces, municipalities, and autonomous regions across China **(Figure 1)**. **Table 1** summarizes their professional distribution: 117 were physicians (27.7%), 132 were pharmacists (31.3%), and 173 were researchers (41.0%). The gender distribution was balanced, with 202 males (47.9%) and 220 females (52.1%). Most participants were between 20 and 49 years of age and had attained at least a college-level education.

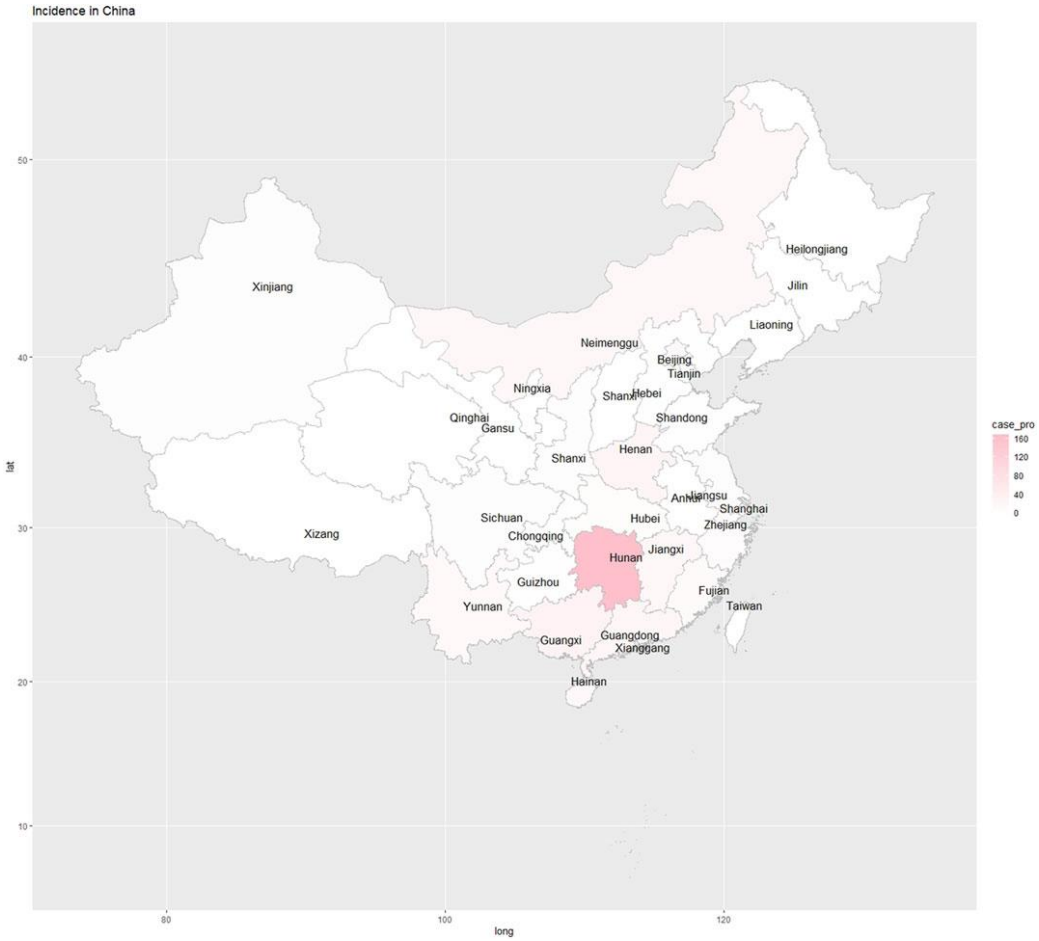


Figure 1. An overall map of PGx participants were from all provinces, municipalities, and autonomous regions.

Table 1. Characteristics of responders.

Characteristic	Physicians	Pharmacists	Researchers	Combined
N	117 (27.7%)	132 (31.3%)	173 (41.0%)	422
Gender				
Male	70 (59.8%)	44 (33.3%)	88 (50.9%)	202(47.9%)
Female	47 (40.2%)	88 (66.7%)	85 (49.1%)	220(52.1%)
Age group			422	
<20	1 (0.9%)	0 (0%)	3 (1.7%)	4(1.0%)
20–29	21 (17.9%)	38 (28.8%)	87 (50.3%)	146(34.6%)
30–39	66 (56.4%)	73 (55.3%)	64 (37.0%)	203(48.1%)
40–49	23 (19.7%)	18 (13.6%)	12 (6.9%)	53(12.6%)
50–59	6 (5.1%)	3 (2.3%)	7 (4.0%)	16(3.8%)
≥60	0 (0%)	0(0%)	0(0%)	0(0%)
Educational level				
Below bachelor	6 (5.1%)	0	2 (1.2%)	8(1.9%)
Bachelor	66 (56.4%)	29 (22.0%)	36 (20.8%)	131(31.0%)
Master	31 (26.5%)	71 (53.8%)	82 (47.4%)	184(43.6%)
PhD	14 (12.0%)	32 (24.2%)	53 (30.6%)	99(23.5%)

Awareness of pharmacogenomics

To assess the level of PGx awareness across different institutions, participants were asked three key questions: Q6, regarding PGx's role in selecting optimal drugs; Q7, concerning PGx's ability to guide correct dosing; and Q8, addressing PGx's potential to prevent serious adverse drug reactions. Overall, the proportion of participants agreeing with these statements was 54.3%, 48.6%, and 57.6%, respectively **(Figure 2a)**. Responders were most aware of PGx's role in predicting adverse drug reactions and least aware of its role in guiding drug selection.

When analyzed by professional group **(Figures 2b-2d)**, pharmacists demonstrated the highest awareness, with agreement rates above 50% for all three questions: 61.4% (Q6), 51.5% (Q7), and 66.7% (Q8). Researchers showed slightly lower, but still generally positive, awareness levels: 56.1% (Q6), 50.9% (Q7), and 60.1% (Q8). Physicians displayed the lowest awareness, with agreement rates below 50% across all three questions: 43.6% (Q6), 41.9% (Q7), and 43.6% (Q8).

Comparative analysis using chi-square tests and logistic regression is presented in **(Tables 2 and 3)**. For Q6, agreement rates differed significantly among the groups ($p = 0.016$). Logistic regression showed that pharmacists were more likely than physicians to recognize PGx's role in drug selection (OR: 1.783; 95% CI: 1.033–3.076; $p = 0.038$), with a similar trend observed for researchers (OR: 1.589; 95% CI: 0.935–2.702; $p = 0.087$). No significant differences were observed among the groups for Q7 ($p = 0.232$); multivariate analysis indicated ORs of 1.242 (95% CI: 0.718–2.149; $p = 0.438$) for pharmacists and 1.426 (95% CI: 0.833–2.439; $p = 0.195$) for researchers. For Q8, significant differences were detected ($p = 0.001$), with pharmacists (OR: 2.199; 95% CI: 1.262–3.834; $p = 0.005$) and researchers (OR: 1.872; 95% CI: 1.093–3.208; $p = 0.022$) showing higher awareness compared to physicians.

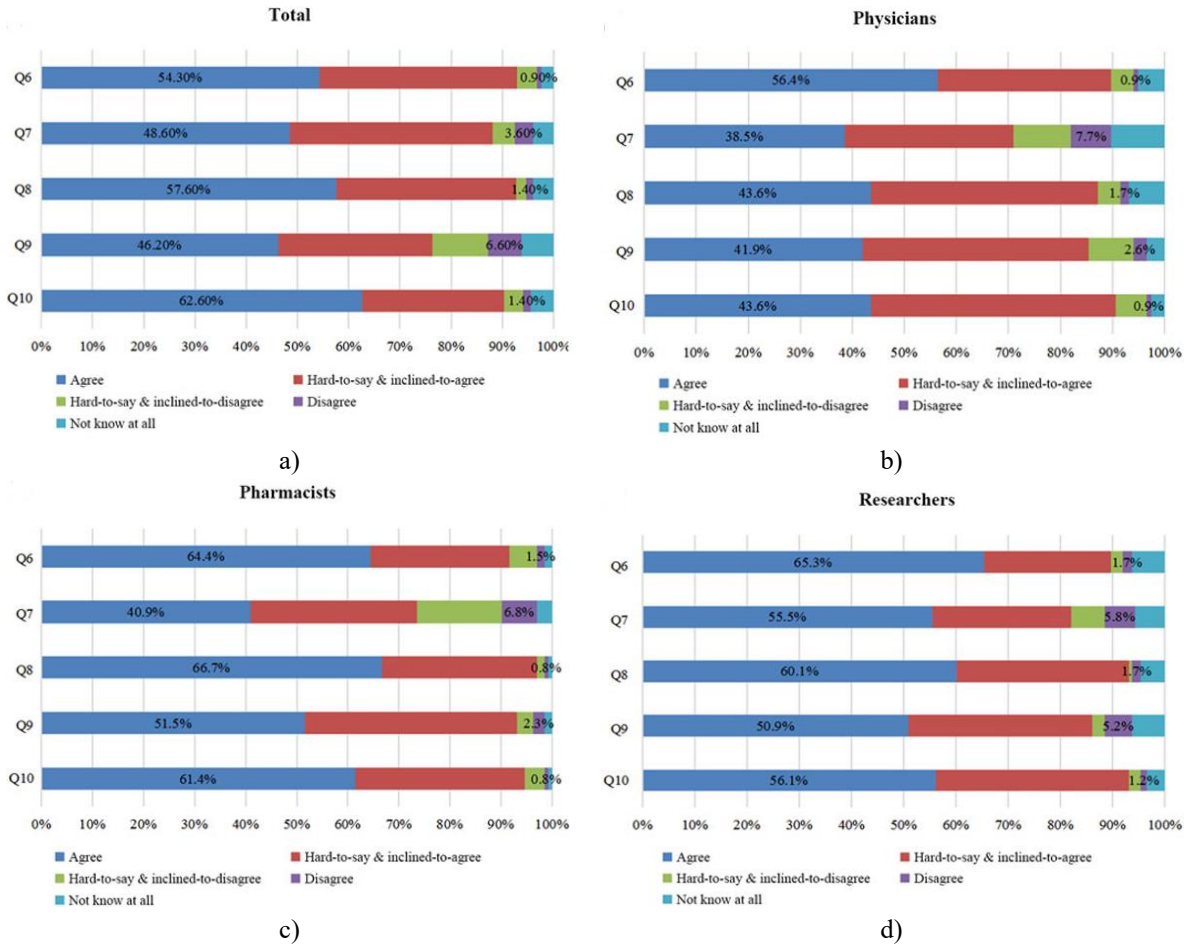


Figure 2. Survey results on PGx awareness among participants. (a) Overall responses to questions Q6–Q10. (b-d) Responses to Q6–Q10 stratified by physicians, pharmacists, and researchers. Q6: Do you think PGx can help in selecting the most appropriate drugs for patients? Q7: Do you believe PGx can assist patients in taking the correct drug dosages? Q8: In your view, can PGx help prevent severe adverse drug reactions? Q9: Do you

think PGx testing can reduce patients' medical costs and economic burden? Q10: Should PGx testing be more widely implemented in clinical practice?

Table 2. Awareness of PGx (χ^2 -test).

Survey question	AgreeN (%)	Not agreeN (%)	Combined*P*
Q6: In your opinion, is PGx capable of aiding in patient selections of optimal drugs?			
Physicians	51 (43.6%)	66 (56.4%)	0.016
Pharmacists	81 (61.4%)	51 (38.6%)	
Researchers	97 (56.1%)	76 (43.9%)	
Q7: In your opinion, can PGx assist patients in using correct doses?			
Physicians	49 (41.9%)	68 (58.1%)	0.232
Pharmacists	68 (51.5%)	64 (48.5%)	
Researchers	88 (50.9%)	85 (49.1%)	
Q8: In your opinion, can PGx assist patients in preventing severe adverse reactions?			
Physicians	51 (43.6%)	66 (56.4%)	0.001
Pharmacists	88 (66.7%)	44 (33.3%)	
Researchers	104 (60.1%)	69 (39.9%)	
Q9:In your opinion, can PGx DNA detection lower the economic burdens and save medical costs for patients?			
Physicians	45 (38.5%)	72 (61.5%)	0.006
Pharmacists	54 (40.9%)	78 (59.1%)	
Researchers	96 (55.5%)	77 (44.5%)	

Table 3. Awareness of PGx (multivariate logistic regression).

Survey response	Adjusted OR (95% CI)	*p* value
Q6: In your opinion, is PGx capable of aiding in patient selections of optimal drugs?		
Occupation		
Pharmacists	1.783 (1.033–3.076)	0.038
Researchers	1.589 (0.935–2.702)	0.087
Physicians	1.0	
Educational level		
PhD	1.339 (0.300–5.986)	0.702
Master	1.350 (0.309–5.901)	0.690
Bachelor	0.693 (0.161–2.989)	0.623
Below bachelor	1.0	
Age group	1.471 (1.119–1.933)	0.006
Q7: In your opinion, can PGx assist patients in using correct doses?		
Occupation		
Pharmacists	1.242 (0.718–2.149)	0.438
Researchers	1.426 (0.833–2.439)	0.195
Physicians	1.0	
Educational level		
PhD	1.042 (0.229–4.733)	0.958
Master	1.501 (0.337–6.689)	0.594
Bachelor	0.594 (0.135–2.614)	0.491
Below bachelor	1.0	
Age group	1.663 (1.262–2.192)	<0.001
Q8: In your opinion, can PGx assist patients in preventing severe adverse reactions?		

	Occupation	
Pharmacists	2.199 (1.262–3.834)	0.005
Researchers	1.872 (1.093–3.208)	0.022
Physicians	1.0	
	Educational level	
PhD	1.541 (0.340–6.982)	0.575
Master	1.531 (0.346–6.771)	0.574
Bachelor	0.692 (0.159–3.017)	0.624
Below bachelor	1.0	
Age group	1.573 (1.186–2.088)	0.002
Q9: In your opinion, can PGx DNA detection lower the economic burdens and save medical costs for patients?		
	Occupation	
Pharmacists	1.114 (0.643–1.930)	0.701
Researchers	2.298 (1.343–3.933)	0.002
Physicians	1.0	
	Educational level	
PhD	0.975 (0.216–4.405)	0.974
Master	0.931 (0.210–4.119)	0.925
Bachelor	0.723 (0.166–3.155)	0.666
Below bachelor	1.0	
Age group	1.546 (1.176–2.032)	0.002

Only 46.2% of participants believed that PGx DNA testing could reduce patients' medical costs (Q9) **(Figure 2a)**. When analyzed by professional groups **(Figures 2b-2d)**, 38.5% of physicians and 40.9% of pharmacists agreed with this statement, reflecting an overall negative perception in these two groups. In contrast, researchers were more optimistic, with 55.5% expressing agreement. Statistical analysis showed significant differences in agreement rates among the three groups ($p = 0.006$) **(Tables 2 and 3)**. Multivariate logistic regression further indicated that pharmacists had an OR of 1.114 (95% CI: 0.643–1.930; $p = 0.701$), while researchers had an OR of 2.298 (95% CI: 1.343–3.933; $p = 0.002$).

For Q10, which addressed whether the clinical implementation of PGx DNA testing should be promoted, 62.6% of all respondents were in favor **(Figure 2a)**. By group, agreement rates were 56.4% for physicians, 64.4% for pharmacists, and 65.3% for researchers **(Figures 2b-2d)**.

Factors limiting the clinical adoption of PGx

Question 11 investigated the main obstacles hindering the clinical use of PGx. Across all participants, the top three barriers identified were the absence of sector-specific standards (20.0%), a lack of large-scale clinical trials (16.8%), and the absence of national guidelines for PGx application in China (15.4%) **(Figure 3a)**. Similar trends were observed across the three professional groups, with minor variations **(Figures 3b-3d)**. Additional factors cited included: PGx tests not being listed in the National Health Commission's catalog of clinical assays (11.1%), lack of standardized reporting for PGx results (10.6%), insufficient knowledge about PGx (9.4%), exclusion of PGx testing from the National Medical Insurance Scheme (9.3%), and the absence of a standardized pricing system for PGx assays (6.8%).

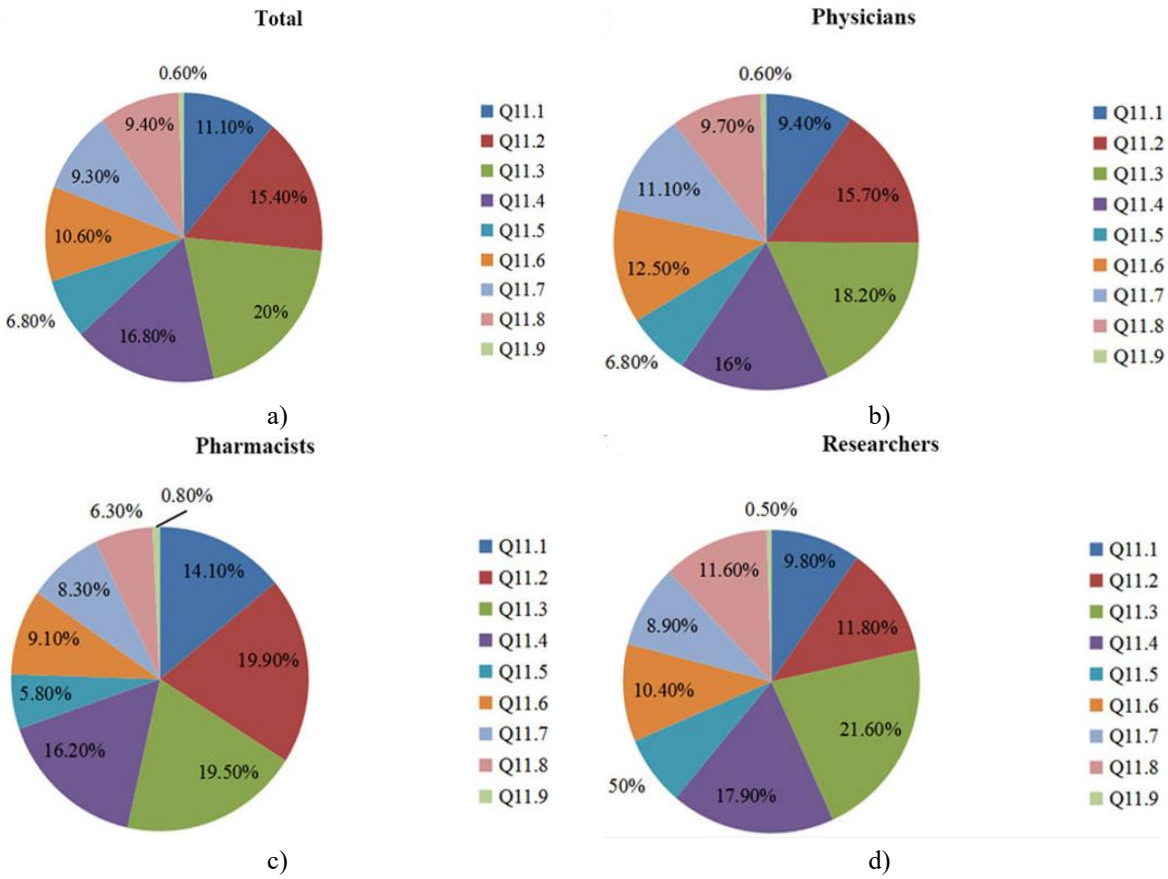


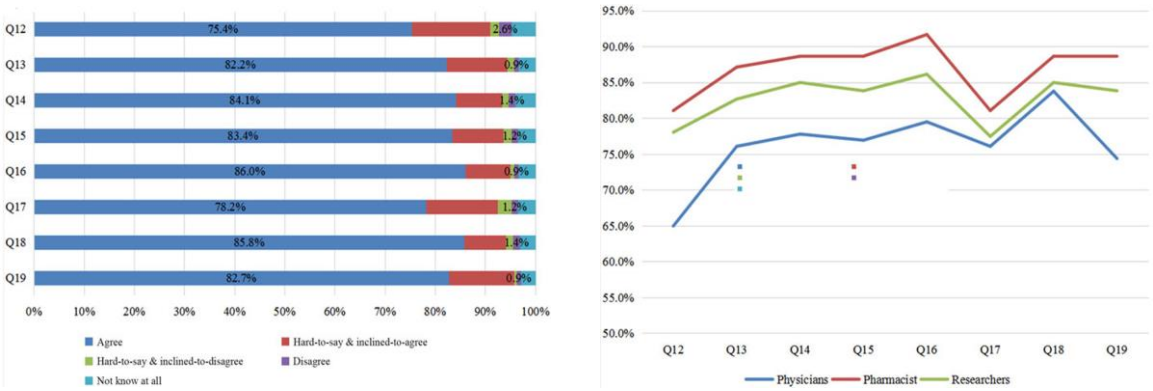
Figure 3. Adoption of PGx

Promoting the clinical implementation of pharmacogenomics

We surveyed participants regarding eight potential strategies to advance the clinical application of PGx (Q12–Q19). These included: Q12, developing regulations for PGx DNA testing; Q13, creating guidelines for individualized PGx-based therapies tailored to Chinese populations; Q14, establishing sector-specific standards for PGx DNA testing; Q15, defining pricing criteria for PGx assays; Q16, standardizing PGx result reporting; Q17, incorporating PGx testing into the National Medical Insurance Scheme; Q18, building a PGx knowledge database for the Chinese population; and Q19, offering PGx-related courses in universities.

Overall, more than 70% of participants supported each of these initiatives **(Figure 4a)**. Respondents emphasized the importance of formulating regulations, guidelines, sector standards, pricing frameworks, and reporting standards, as well as developing a knowledge database, integrating PGx testing into medical insurance, and providing academic courses on PGx.

When stratified by professional group **(Figure 4b)**, pharmacists showed the highest level of support for all eight measures, with approval rates of 81.8%, 87.9%, 88.6%, 88.6%, 91.7%, 81.1%, 88.6%, and 88.6%, respectively. Researchers also expressed strong support (78%, 82.7%, 85%, 83.8%, 86.1%, 77.5%, 85%, and 83.8%), while physicians were comparatively less supportive, though still positive (65%, 76.1%, 77.8%, 76.9%, 79.5%, 76.1%, 83.8%, and 74.4%). These results suggest that pharmacists are particularly eager for initiatives to further improve PGx clinical implementation.



(a) (b)

Figure 4. Survey on Facilitating the Clinical Adoption of PGx (a) Responses from all participants regarding Q12–Q19. (b) Responses to Q12–Q19 broken down by physicians, pharmacists, and researchers. Q12: Should the government establish regulations for PGx DNA testing? Q13: Is it necessary to develop guidelines for individualized PGx-based therapy for the Chinese population? Q14: Should sector-specific codes for PGx DNA testing be implemented? Q15: Is it necessary to set pricing standards for PGx DNA testing? Q16: Should reporting standardization for PGx DNA testing be formulated? Q17: Should PGx DNA testing be included in the National Medical Insurance Scheme? Q18: Is it important to create a PGx knowledge database for Chinese populations? Q19: Should colleges offer courses related to PGx?

Current status of PGx testing implementation

Institutions where participants worked were also assessed for the availability of PGx testing (Q20). As illustrated in **Figure 5**, PGx assays were performed for a range of drugs, including warfarin, clopidogrel, statins, nitroglycerin, folic acid, carbamazepine, aspirin, morphine, fentanyl, efavirenz, voriconazole, and thiopurine. Among these, warfarin and clopidogrel were the most commonly tested medications.

Figure 5. Word Cloud Showing Frequency of PGx Drug Testing

The word cloud represents the frequency of drugs tested using PGx in participants' institutions. The size of each drug name corresponds to the frequency of testing.

The clinical adoption of PGx is gradually increasing in mainland China. To evaluate the current status, we conducted this survey among physicians, pharmacists, and researchers. Our results showed that less than half of physicians expressed agreement with PGx implementation, whereas more than 50% of pharmacists and researchers had a positive attitude toward PGx testing.

In comparison, surveys from the United States reported that 97.6% of physicians recognized the influence of genetic factors on drug therapy, and a Dutch survey found that 99.7% of pharmacists believed drug response could

be affected by patient genotypes [13, 14]. These findings suggest that awareness of hereditary factors affecting drug response is lower among Chinese physicians and pharmacists.

Most physicians and pharmacists in our survey did not consider PGx testing to reduce patients' economic burden. In China, no standardized pricing exists for PGx testing. Typically, institutions charge around RMB 300 per mutation locus, with costs for testing one drug approaching RMB 1,000. For instance, warfarin therapy generally requires two loci (CYP2C93 and VKORC1 -1639G>A), costing a minimum of RMB 600, while clopidogrel testing involves three loci (CYP2C192, CYP2C193, CYP2C1917) with a minimum cost of RMB 900. Testing multiple drugs could easily cost thousands or even tens of thousands of yuan, often exceeding the cost of the drugs themselves or alternative treatments. This high cost may contribute to physicians' and pharmacists' hesitancy toward PGx, given potential concerns over cost-effectiveness.

Despite this, 56.4% of physicians, 64.4% of pharmacists, and 65.3% of researchers supported clinical implementation of PGx testing, though agreement rates remained below 70%. Public awareness of PGx is still limited in China, and many perceive it as a potential financial burden. Furthermore, there is a lack of pharmacoeconomic analyses of PGx in China, which are critical for educating healthcare providers and promoting its broader clinical adoption.

Our survey identified three primary barriers to PGx implementation in China: the absence of standardized sector codes for PGx clinical application, limited large-scale PGx-based clinical trials, and the lack of national guidelines for PGx use in Chinese patients. Existing pharmacogenomics surveys have not systematically examined the factors affecting clinical adoption, despite their importance. Some researchers suggest that challenges such as testing technology, report interpretation, and testing costs remain major obstacles [17]. However, with advances in sequencing technologies, PGx testing is becoming more accessible, and proper reporting remains a key factor influencing its clinical use.

Overall, most respondents expressed optimism regarding the future of PGx in China. However, they emphasized that effective implementation requires the establishment of PGx-related regulations, clinical guidelines, sector standards, reporting standardization, and a comprehensive knowledge database. Additionally, PGx testing should be incorporated into the National Medical Insurance Scheme, and relevant educational courses should be offered at universities.

The Division of Pharmacogenomics of the Chinese Pharmacological Society has been instrumental in advancing PGx research and development in mainland China. This national organization is working to accelerate PGx research and establish standardized application guidelines. Several provincial and local scientific organizations have also formed PGx-focused committees to strengthen research and implementation efforts. For example, the Hunan Provincial Medical Association has a subcommittee dedicated to Translational Pharmacogenomics, and the Pharmaceutical Associations of Hunan, Jiangsu, and Anhui provinces have established special committees for PGx [18, 19]. Moreover, a national PGx database (http://www.chnpgxc.com/) has been developed with the mission of serving as a central knowledge hub, providing sector standards and application guidelines, supporting clinical decision-making, offering educational resources, recommending individualized therapy strategies, and facilitating precise drug development. Such initiatives are expected to further advance PGx research and clinical application in China.

PGx tests are currently offered by some institutions for a range of drugs, including cardiovascular agents (e.g., warfarin, clopidogrel, statins, nitroglycerin, folic acid, aspirin), antiepileptics (e.g., carbamazepine), analgesics and anesthetics (e.g., morphine, fentanyl), antibiotics (e.g., efavirenz, voriconazole), and antineoplastics (e.g., thiopurines). In our survey, some respondents provided only drug categories, such as antineoplastics, antiplatelets, hypotensives, and antipsychotics, without specifying individual drugs. Consequently, detailed information on drug-specific PGx testing was limited.

It is also important to note that our survey focused on physicians, pharmacists, and researchers, excluding employees of third-party genetic testing agencies and other stakeholders. Currently, most PGx testing is conducted by these third-party agencies, while hospital-based testing remains limited. This is particularly evident for targeted antineoplastic therapies, where PGx testing is often critical for optimizing treatment. This may explain why antineoplastic agents were not frequently listed by respondents in our survey.

Limitations

Our survey has several limitations. First, we employed a new online survey method using the Wenjuanxing platform and WeChat, which is convenient and allows rapid data collection. However, this approach also has

drawbacks. For instance, the total number of individuals who accessed the survey link is unknown, and only interested professionals completed the questionnaire, making it impossible to calculate response rates.

Second, our study focused on physicians, pharmacists, and researchers, all of whom have relatively high educational backgrounds. Pharmacogenomics is not widely included in undergraduate curricula in China, and only a few universities offer it as an elective in postgraduate programs. This likely explains the high educational level observed among respondents and suggests that our results mainly reflect the understanding of PGx among healthcare providers practicing in China. Future studies should expand to the general population to gain a broader understanding of pharmacogenomics awareness in China.

Third, the implementation of PGx and factors affecting it may vary across different practice settings. Although we included a question (Q20) about respondents' practice environments, few participants answered it, possibly due to privacy concerns or other unknown reasons.

Fourth, while we attempted to assess the factors influencing PGx application comprehensively, more detailed information would have been valuable. For example, understanding whether respondents had prior PGx training or education could provide additional insights. Due to the anonymous nature of the survey, we were unable to trace respondents' educational or training backgrounds in pharmacogenomics.

Conclusion

This survey assessed PGx knowledge and application among physicians, pharmacists, and researchers in China. Our findings indicate that many healthcare providers, particularly physicians, do not fully recognize the importance of PGx in drug therapy. The results provide valuable insights into the current status of PGx implementation in China. Although research in pharmacogenomics has progressed rapidly in recent years, its clinical adoption still faces significant challenges and has substantial room for growth [20].

Acknowledgments: We thank all individuals involved in the response to the survey of pharmacogenomics testing.

Conflict of Interest: None

Financial Support: This work was supported by National Natural Science Foundation of China (81974511), the National Science and Technology Major Project of China on Novel Drug Discovery and Development (2019ZX09201-002-006, 2020ZX09201010), Natural Science Foundation of Guangdong Province (2018A030313871), Natural Science Foundation of Hunan Province (2020JJ4832) and the New Xiangya Talent Project of the Third Xiangya Hospital of Central South University (JY201505).

Ethics Statement: None

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