Republic of Iraq
Ministry of Higher Education &
Scientific Research

AL ZAHRAWI UNIVERSITY COLLEGE
DEPARTMENT OF PHARMACY

Awareness and Implementation of Pharmacogenetic Testing in Iraqi Hospitals: An Explorative Pilot Study

The students

Ali Akram Khazal

Huda Saad Sami

Mustafa Haider Sadiq

Zainab Jameel Jassim

Supervision

Lec. Dr. Ali Hassan Ijam

(Ph.D. Pharmacology & Toxicology)

بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

وَمَا تَوْفِيقِي إِلَّا بِاللَّهِ ۚ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيب

صدقَ اللهُ العليُّ العظيم

" سورة هود من الآية 88"

Contents

Abstract

Pharmacogenetics explores how genetic variations influence drug response, enhancing personalized medicine. While developed nations have integrated pharmacogenetics into clinical practice, low- and middle-income countries like Iraq face challenges such as limited awareness, education gaps, and insufficient infrastructure. Studies indicate that healthcare professionals, including pharmacists and doctors, often lack formal training, affecting the adoption of pharmacogenetic testing. This research aims to compare the awareness, knowledge and attitudes of pharmacists versus doctors in Iraq, highlighting the need for targeted education and policy support to advance pharmacogenetics in clinical practice.

Methods

This cross-sectional study, conducted from October 2024 to January 2025 in three Iraqi hospitals, assessed healthcare providers' awareness, knowledge, and attitudes toward pharmacogenetic testing. Data was collected through face-to-face interviews using a structured questionnaire covering demographics, knowledge, attitudes, and implementation challenges. Statistical analysis was performed using SPSS, GraphPad Prism, and Pearson correlation applied.

Results

The study included 250 healthcare professionals, with a majority of doctors (66.4%) and a nearly equal gender distribution. Awareness of pharmacogenetic testing was moderate, with pharmacists (77%) significantly more aware than doctors (38%). Knowledge scores revealed that doctors (82.1%) had higher pharmacogenetic knowledge than pharmacists (65.3%), with misconceptions persisting in certain areas. Participants expressed positive attitudes toward pharmacogenetics, with 51% believing it is the future of medicine and 47% supporting routine testing. The main barriers to implementation were lack of knowledge (100%), high costs (94%), and limited testing devices (92%).

Conclusion

Our findings provided baseline information on knowledge, attitude, and interest toward pharmacogenetics among health professionals. The significant contrast between awareness and knowledge of pharmacogenetic testing among pharmacists and doctors highlights the need for more effective education of physicians and pharmacists on pharmacogenetics and its clinical application.

Keywords: pharmacogenetic testing, knowledge, attitude, personalized medicine.

1. Introduction

Pharmacogenetics, a subset of pharmacogenomics, integrates pharmacology and genetics to optimize drug therapy tailored to an individual's genetic makeup. This emerging field focuses on how genetic variation influences drug response, encompassing both efficacy and safety [(1)]. While pharmacogenetics traditionally examines single or limited gene variations, pharmacogenomics extends its scope to whole-genome analyses, providing a more comprehensive view of genetic influences on drug action [(2)]. Advances in the Human Genome Project have catalyzed this field, offering insights into genetic polymorphisms and their implications for personalized medicine [(3)]. For example, pharmacogenetic testing identifies patients susceptible to adverse drug reactions or suboptimal responses, enabling tailored therapeutic interventions [(4)] .

Pharmacogenetics represents a transformative approach to healthcare, focusing on the genetic underpinnings of drug response to deliver precise, effective, and safe therapeutic interventions [(5)]. According to *Abdela et al.* (2017), pharmacogenetics allows healthcare professionals to predict a patient's drug response and mitigate adverse drug reactions. This capability is particularly valuable for addressing variability in treatment outcomes that arise from genetic diversity within populations [(6)].

The integration of pharmacogenetics into clinical practice has already yielded significant benefits in developed nations. As *Elewa et al.* (2015) highlight, genetic testing for specific markers, such as cytochrome P450 2C19 (CYP2C19) and human leucocyte antigen (HLA-B*1502), has been instrumental in optimizing drug therapies for cardiovascular diseases and epilepsy, respectively [(7)]. Similarly, *Za et al.* (2014) emphasize that the adoption of pharmacogenetics in Malaysia has contributed to reducing healthcare costs by preventing adverse reactions and improving drug efficacy [(8)].

The global relevance of pharmacogenetics is underscored by its potential to improve therapeutic outcomes across diverse healthcare settings. For instance, in high-income countries, pharmacogenetic applications have already demonstrated significant

clinical benefits, such as reducing hospitalizations due to adverse drug reactions and optimizing treatments for complex diseases [9]. For developing nations like Iraq, where genetic diversity and resource constraints pose unique challenges, implementing pharmacogenetics can address disparities in drug response and improve overall healthcare outcomes [10]. In Qatar, for instance, studies revealed that pharmacogenetic testing could reduce healthcare costs by preventing unnecessary treatments and hospital admissions [7]. These findings highlight the critical role of pharmacogenetics in bridging disparities in healthcare delivery and advancing precision medicine worldwide.

Many health professionals are not competent enough in the field of pharmacogenomics, even though results from different studies promote pharmacogenomic practice and education. They continue to lack confidence and education in this field [11]. If the concept of pharmacogenomic science is to be translated into clinical practice, all those involved in health care service including physicians, nurses, and pharmacists need to be educated well about pharmacogenomics [12].

Several studies have explored the knowledge, attitudes, and perceptions of healthcare professionals including physicians and pharmacists toward pharmacogenetics worldwide. A study in Ethiopia revealed limited knowledge but positive attitudes among healthcare providers, with over 80% expressing interest in receiving training on pharmacogenetics [6]. Similarly, a cross-sectional survey in India highlighted the growing awareness of pharmacogenomics' value in personalizing treatments, emphasizing the need for its integration into medical curricula [13]. In Jordan, pharmacists exhibited moderate knowledge but strong enthusiasm for pharmacogenetics' clinical applications. However, concerns about privacy and insurance coverage were significant barriers [3]. Research in Egypt underscored the low knowledge levels among healthcare practitioners but noted a consensus on the field's potential to improve therapeutic outcomes [2]. In Zimbabwe, pharmacists and students demonstrated a keen interest in pharmacogenetics but identified inadequate training as a major challenge [9]. Studies in Kuwait and Malaysia also highlighted the role of education in addressing knowledge gaps. For instance, Albassam *et al*. (2018) reported that only 9% of healthcare professionals in Kuwait had received formal training in pharmacogenetics,

underscoring the need for targeted educational interventions [1]. Similarly, Za *et al.* (2014) found that Malaysian healthcare providers favored continuous professional education programs to enhance their pharmacogenetics competencies [8].

Globally, the integration of pharmacogenetics into healthcare systems is advancing, albeit unevenly. Countries with robust educational frameworks and supportive policies, such as the United States and several European nations, are at the forefront of pharmacogenetics implementation. In contrast, low- and middle-income countries, including Iraq, face unique challenges that necessitate tailored solutions [14]. By examining these studies, this research aims to provide actionable insights for promoting pharmacogenetics in Iraqi hospitals, fostering a culture of personalized medicine.

Despite the availability of pharmacogenetic tests, their clinical application in patient care is reported to be slow. Previous studies have identified major barriers to healthcare providers' acceptance of pharmacogenetics testing into their practice. These barriers include a lack of awareness and education among healthcare providers, limited access to genetic testing facilities, and insufficient funding for research and infrastructure [7, 15,16]. Hence, the provision of enhanced genetic education to healthcare professionals at both the undergraduate and in-service levels is of paramount importance to the implementation of pharmacogenetics testing in clinical practice.

In addition, the integration of pharmacogenetics into healthcare systems requires robust policy frameworks and clinical guidelines. Studies in Kuwait and Malaysia have emphasized the need for governmental support and international collaboration to overcome these challenges [1, 8]. Addressing these barriers is essential for realizing the full potential of pharmacogenetics in clinical practice

Several studies have investigated the knowledge and attitudes of pharmacists towards pharmacogenomics and its application [17,18]. Others have also examined similar outcomes in doctors [19, 20] . However, to our knowledge, none of these studies have compared the attitude of pharmacists versus doctors towards the delivery of pharmacogenomics services in Iraq.

Conducting this study aims is to assess the awareness, knowledge, and attitudes of pharmacists compared with doctors towards pharmacogenomics and its implications by a survey questionnaire to all pharmacists and doctors currently working in a large medical corporation in Iraq. By fostering awareness and education among healthcare providers, this study seeks to bridge the gap between pharmacogenetic potential and clinical reality in Iraq.

2. Materials and Methods

➢ Study design & participants

The present study is a preliminary descriptive cross-sectional questionnaire-based study designed with an eligible convenient sample (250 participants) and conducted from October 2024 to January 2025 to assess the level of awareness and knowledge of healthcare providers (doctors, pharmacists) , attitudes about pharmacogenetic testing and evaluate the potential benefits and challenges of incorporating pharmacogenetic testing into routine clinical care for personalized medicine in an Iraqi hospital.

➢ Study setting

The study was carried out in three hospitals in Iraq: Imam Hussein Teaching Hospital, Imam Al-Hassan Al-Mujtaba Hospital in Karbala, and Al-Sadr Medical City in Najaf.

Inclusion Criteria:

- Practicing **doctors** and **pharmacists** working in the Imam Hussein Teaching Hospital, Imam Al-Hassan Al-Mujtaba Hospital in Karbala, and Al-Sadr Medical City in Najaf.
- Participants with at least **one year** of professional experience
- Willingness to participate in the study and provide informed consent
- Ability to understand and complete the questionnaire in English

Exclusion Criteria:

- Medical and pharmacy students or interns with less than one year of experience
- Healthcare providers working outside the selected hospitals
- Participants who declined to complete the survey
- Incomplete or inconsistent questionnaire responses

- **Data Collection**

Data collection was conducted through face-to-face interviews with pharmacists and doctors using a multicomponent questionnaire. Each interview lasted approximately 10–15 minutes. Consent was considered implied upon participants' agreement to complete the questionnaire.

- **Survey questionnaire**

Based on a literature review of similar previous studies, the study survey was adapted from validated questionnaires that were previously used[1,2,13]. Participants were administered a paper-based survey in English to evaluate their awareness, knowledge, attitudes, and perceptions of challenges regarding pharmacogenetic testing. Return of the survey was considered an agreement to participate in the study. The surveys were distributed hand to participants and the survey was anonymous and voluntary. The survey consisted of four sections covering the following topics: first, participants' demographics and professional characteristics; second, participants' knowledge and awareness of pharmacogenetics; third, participants' attitudes toward pharmacogenetics and its clinical implications; and fourth, participants' perspectives regarding the challenges of implementing pharmacogenetics in the clinical setting.

The awareness section of the survey included one question Have you heard about pharmacogenetic testing before and seven questions (i.e., true, false, not sure) assessing clinical pharmacogenetic knowledge. Each correct answer was assigned one point, while

each incorrect or ‘not sure’ answer was assigned zero points. The total number of correct questions was divided by seven and multiplied by 100 to give the participant’s ‘knowledge score.’

The third section of the survey consisted of eight questions assessing participants’ attitudes toward pharmacogenetics and its clinical implications. Participants were asked to rate the extent to which they agreed with each statement

The last section of the survey asked participants to indicate challenges and barriers to the implementation of pharmacogenetic testing using a predefined list, in other words, Lack of knowledge/awareness, lack of testing device, High costs of testing/ limited funding, Lack of clinical guidelines, Policy or administrative barriers, Lack of time , Shortage of qualified staff. Participants could select more than one option, and a free response section was available to capture other items that were not on the list.

➢ Statistical Analysis

The data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0, Microsoft Office 2019, and GraphPad Prism version 9.0. Statistical data, including the mean and standard deviation, were measured to describe the variables. The degree of association between continuous variables was calculated by the Pearson correlation coefficient, and the results were considered statistically significant when the p-value was less than 0.05.The descriptive statistics were applied and the categorical variables were summarized as frequencies and percentages.

In relation to the seven questions for assessing knowledge, a score of one point was given if the right answer was chosen and a score of zero was given if the wrong answer or `not sure was chosen. The percentage knowledge score (PKS) was calculated by dividing the participant's score by 7 (the maximum score) and multiplying by 100.

3. Results

- **Demographic Characteristics of Study Participants**

A total of 250 healthcare professionals participated in the study, including 84 pharmacists (33.6%) and 166 doctors (66.4%). Among the respondents, most of them were females (52.8%, n=132). The majority responses were received from doctors, of which 22.8% of bachelor's degree (n=57) were the major contributors, as demonstrated in Table 1.

- **Awareness of Pharmacogenetic Testing: A Survey Analysis**

Regarding the overall awareness of Pharmacogenetic Testing, out of 250 participants, 128 (51.2%) have heard about pharmacogenetic testing, while 122 (48.8%) have not, this suggests that awareness of pharmacogenetic testing is relatively balanced among the respondents, with only a slight majority being aware. Table 2

Regarding the awareness of Pharmacists and doctors separately, among pharmacists (n=84), 65 (77%) are aware of pharmacogenetic testing, while 19 (23%) are not. Among doctors (n=166), only 63 (38%) are aware, whereas 103 (62%) are not. This means that pharmacists are significantly more likely to have heard about pharmacogenetic testing compared to doctors. Table 2

Table 1: Demographic and professional Information

Questions Persons (250)		Frequency percentages			P-value
		Pharmacist 84(33.6%)	Doctor 166(66.4%)	Total **250(100%)**	
1-Age	25-35	20(24%)	30(18%)	50(20%)	0.7
	36-46	24(29%)	41(25%)	65(26%)	
	47-57	30(36%)	45(27%)	75(30%)	
	>60	10(11%)	50(30%)	60(24%)	
2-Gender	Male	(48%)40	(47%)78	118(52.8%)	
	Female	(52%)44	(53%)88	132(47.2%)	
3-Extra credentials apart from Bachelors degree	Academic	(%)20	(15%)25	45(18%)	0.05
	Bachelors	(%)20	(22%)37	57(22.8%)	
	Master	13(%)	(21%)34	47(18.8%)	
	PhD	(%)14	(24%)40	54(21.6%)	
	Board	(%)17	(18%)30	47(18.8%)	
4-Years of Experience	1-10	35(42%)	(51%)85	120(48%)	0.01
	11-20	25(30%)	30(18%)	55(22%)	
	21-30	(12%)10	26(16%)	36(14.4%)	
	31-40	(16%)14	(15%)25	39(15.6%)	
5Department	Pharmacy	(2%)2	(5%)8	10(4%)	0.01
	Cardiologist	0(0%)	(11%)18	18(7.2%)	
	Dentist	0(0%)	21(13%)	21(8.4%)	
	Hospital pharmacy	(6%)5	17(10%)	22(8.8%)	
	Pediatrician	0(0%)	23(14%)	23(9.2%)	
	Ophthalmologist	0(0%)	13(8%)	13(5.2%)	
	Surgery	0(0%)	16(9.6%)	16(6.4%)	
	Nephrologist	0(0%)	13(8%)	13(5.2%)	
	Dermatologist	0(0%)	14(8.4%)	14(5.6%)	
	Gastrointestinal	0(0%)	19(11.4%)	19(7.6%)	
	Gynaecologist	0(0%)	11(6.6%)	11(4.4%)	
	Orthopedic	0(0%)	7(4.2%)	7(2.8%)	
	Rotator	0(0%)	12(7.2%)	12(4.8%)	
	Venereologist	0(0%)	14(8.4%)	14(5.6%)	
	Respiratory	0(0%)	13(8%)	13(5.2%)	
	Nephrologist	0(0%)	11(6.6%)	11(4.4%)	
	Emergency	0(0%)	13(8%)	13(5.2%)	

Table 2: Awareness of Pharmacogenetic Testing

5- Have you heard about pharmacogenetic testing before Total :250	Frequency& percentages	Yes	No	P-value
Pharmacist	84(33.6%)	65(77%)	19 (23%)	0.01
Doctor	166(66.4%)	63(38%)	103(62%)	
Total	250(100%)	128(51.2%)	122 (48.8%)	

- **Knowledge of Pharmacogenetic Testing: A Survey Analysis**

Regarding the knowledge score of Pharmacogenetic testing among participant, on average, doctors have a higher knowledge score (82.1%) compared to pharmacists (65.3%) as mentioned in table 3 , Since p = 0.01, this indicates a statistically significant difference between the two groups

Regarding the knowledge questions of Pharmacogenetic testing, In most questions, doctors seem to have a slightly higher percentage of correct responses than pharmacists, though the differences are not always large. The highest correct response was observed for question 10 (inter-ethnic variation in drug response) with 51% correct responses, indicating moderate awareness of genetic influence on drug response among both groups. The lowest correct response rate was for question 12 (The drug response can be predicted by using genetic biomarkers) with only 39% correct responses, indicating a major misconception about accessibility. These findings underscore the importance of integrating pharmacogenomics education into the curriculum to enhance students' understanding and application of genetic information in clinical practice, table 4.

Table 3: Knowledge score percentage

Knowledge score percentage Mean ± SD			
Correct Response Total: No.128	**Pharmacist No.65**	**65.3± 12.3**	**P-value 0.01**
	Doctor No.63	**82.1± 24.1**	

- **Attitudes toward Pharmacogenetics and Its Clinical Implication:**

Our goal in conducting this study was to ascertain how the participants felt about the potential applications of pharmacogenomics (PGx). The results indicated a good belief in the benefits of PGx testing, as depicted in Table 5. 47%(n=60) of participants thought that PGx testing should be a routine part of patient care, and 51%(n=65) felt that pharmacogenetic testing improves patient outcomes. Additionally, 42%(n=54) thought PGx testing can improve their future work in choosing the right drug at the right dose, while 48%(n=62) believed that PGx testing would aid in selecting the appropriate route of drug administration, and 48%(n=62) thought it would reduce adverse drug reactions (ADRs). A significant portion, 42%(n=54), believed that PGx testing would decrease drug development costs. The survey also revealed a high level of interest in PGx among the participants. Specifically, 51%(n=65) expressed a desire to learn more about PGx. Furthermore, 51%(n=65) viewed PGx testing as the future of medicine. These findings highlight the positive attitudes and high levels of interest in PGx among participants, underscoring the potential for integrating PGx education and applications into future healthcare practices.

Table 4: Knowledge of Pharmacogenetic Testing

Questions Persons	Response	Pharmacist No.65	Doctor No.63	Total: No.128
6-Genetic determinants of drug response change over a person's lifetime.	Correct	15(30 %)	35(70 %)	50(39%)
	incorrect	50(70%)	28(30%)	78(61%)
7-Pharmacogenomic testing is available for most medications	Correct	(42%)20	(58%)28	48(38%)
	incorrect	45(58%)	35(42%)	80(62%)
8- There is an inter-ethnic variation in the drug response	Correct	(46%)30	(54%)35	65(51%)
	incorrect	35(54%)	28(46%)	63(49%)
9- **Pharmacogenetic testing has an important role in individualizing response to medication**	Correct	(34%)20	(66%)40	60(47%)
	incorrect	45(66%)	23(34%)	68(53%)
10- **Pharmacogenetic testing has an important role in identifying drug – drug interaction**	Correct	25(38 %)	40(62 %)	65(51%)
	incorrect	40(62%)	23(38%)	63(49%)
11- **High risk of drug toxicity can be due to variants**	Correct	(34%)20	(66%)40	60(47%)
	incorrect	45(66%)	23(34%)	68(53%)
12- **The drug response can be predicted by using genetic biomarkers**	Correct	(38 %)25	(40 %)25	50(39 %)
	incorrect	40(62%)	38(60%)	78(61%)

Table 5 : Attitudes toward Pharmacogenetics and Its Clinical Implication

Questions		Pharmacist	Doctor	Total	P-value
		Frequency & percentages			
14- - Do you think that pharmacogenetic testing should be a routine part of patient care Total: 128	Yes	20(34%)	40(66%)	60(47%)	0.01
	No	20(46%)	24(55%)	44(34%)	
	Not Sure	14(58%)	10(42%)	24(19%)	
15- Do you believe pharmacogenetic testing improves patient outcomes Total: 128	Yes	(46%)30	(54%)35	65 (51%)	0.01
	No	(42%)20	(58%)28	48(37%)	
	Not Sure	(33%)5	10(67%)	15(12%)	
16.Do you think that pharmacogenomics testing can improve your future work in choosing the right drug at the right dose Total: 128	Yes	(37%)20	(63%)34	54(42%)	0.02
	No	(44%)24	(56%)30	54(42%)	
	Not Sure	(50%)10	10(50%)	20(16%)	
17- Do you think pharmacogenomics testing will help you to choose the right route of drug administration Total: 128	Yes	(32%)20	(68%)42	62(48%)	0.02
	No	(48%)20	(52%)22	42(33%)	
	Not Sure	(42%)10	(58%)14	24(19%)	
18- **Do you think that pharmacogenomics testing will help to decrease the number of adverse drug reactions** Total: 128	Yes	(32%)20	(68%)42	62(48%)	0.02
	No	(47%)20	(53%)23	43(34%)	
	Not Sure	(43%)10	(56%)13	23(18%)	
19- **Do you think pharmacogenomics testing will help to decrease the cost of developing new drugs** Total: 128	Yes	(37%)20	(63%)34	54(42%)	0.5
	No	(44%)24	(56%)30	54(42%)	
	Not Sure	(50%)10	10(50%)	20(16%)	
20- **Do you want to know more about pharmacogenomics** Total: 128	Yes	(46%)30	(54%)35	65 (51%)	0.02
	No	(42%)20	(58%)28	48(37%)	
	Not Sure	(33%)5	10(67%)	15(12%)	
21- **Do you feel that pharmacogenomics is the future** Total: 128	Yes	(31%)20	(69%)45	65(51%)	0.02
	No	(25%)10	(75%)30	40(31%)	
	Not Sure	(44%)10	(56%)13	23(18%)	

- **Assessment of challenges & barriers to implementation of pharmacogenetic testing**

The survey respondents also identified several challenges and barriers to implementation of pharmacogenetic testing (Figure 1). Lack of knowledge/awareness (100%) was the most commonly reported challenge, followed by High costs of testing/ limited funding (94 %), lack of testing device (92%), Lack of time (92 %), lack of clinical guidelines (86 %), Policy or administrative barriers (74 %), Shortage of qualified staff (43 %). The frequency of identified challenges did not differ significantly between pharmacists and physicians.

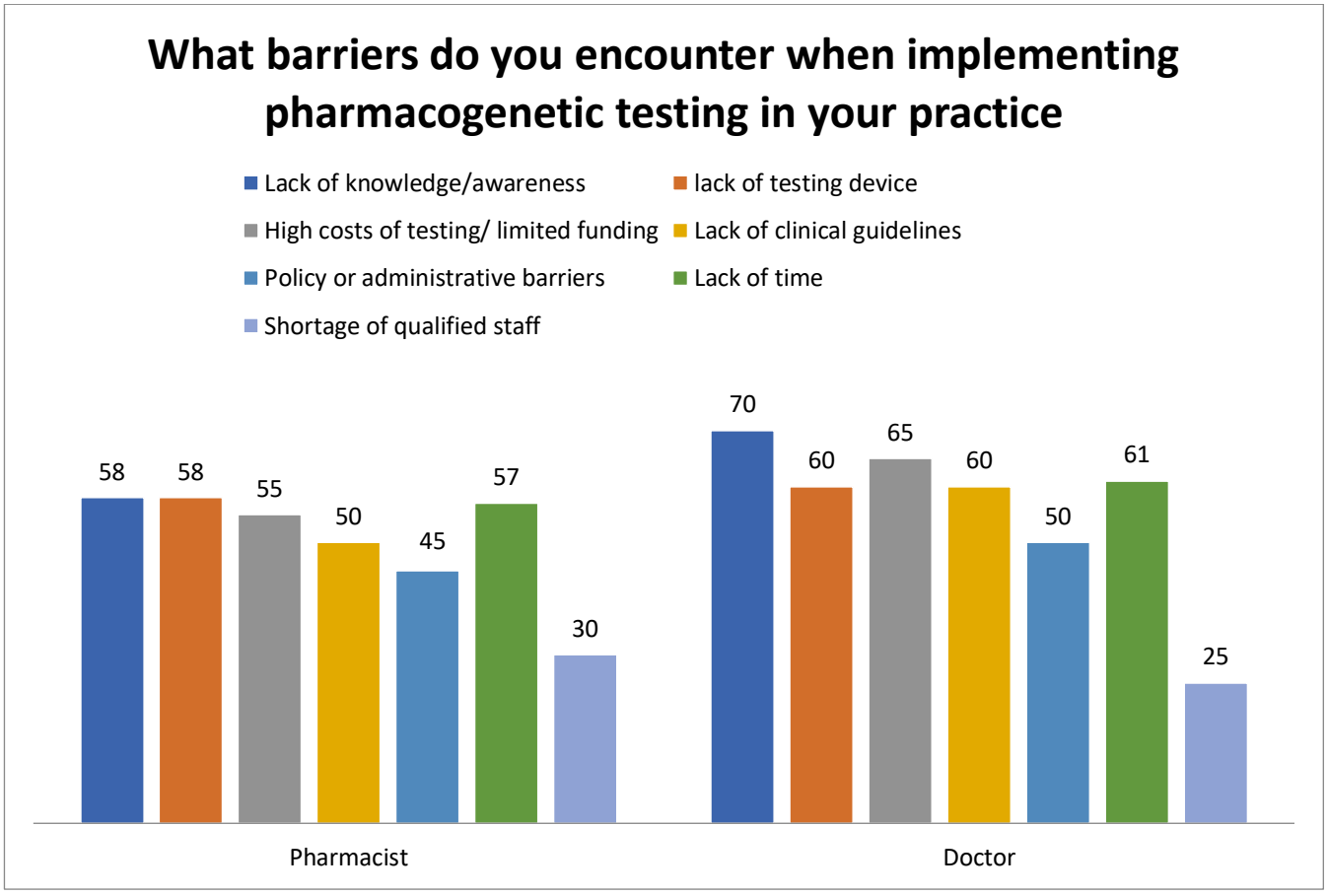

Figure 1: presents the distribution of the physicians' and pharmacists' responses regarding the barriers facing the application of pharmacogenetic testing in their practice settings.

4. Discussion

Pharmacogenomics offers a great promise to better understand the patients' genetic risk and drug response to improve therapeutic outcomes. It has also generated important additional clinical information related to the disease and drugs in the past 50 years. However, integrating pharmacogenomic knowledge into clinical practice is still a challenge. It is important for all health professionals (doctors and pharmacists) to use pharmacogenomic information for optimal medication use [21].

The current study highlights important concerns about the level of awareness, knowledge and attitude towards pharmacogenetics of pharmacists versus doctors in Iraq. The present findings contribute to the limited amount of existing literature in the developing countries about these outcomes and allow for important comparative work with existing and future investigations in Iraq.

To the best of our knowledge, however, this is the first survey to be performed in Iraq which investigated the current level of physicians' and pharmacists' knowledge, attitude, challenge towards pharmacogenetics and its clinical implications.

The first findings of this study reveal notable differences in awareness and knowledge toward pharmacogenetic testing between pharmacists and doctors. Pharmacists exhibited higher awareness (81% vs. 36% for doctors), yet doctors demonstrated superior knowledge scores (82.1% ± 24.1 vs. 65.3% ± 12.3 for pharmacists), with these differences being statistically significant ($p = 0.01$). This disparity suggests that while pharmacists are more familiar with the concept of pharmacogenetic testing, they may lack the in-depth understanding necessary for clinical application. Conversely, doctors, despite lower overall awareness, possess a deeper comprehension of their principles and implications, likely due to specialized medical training.

This observation is consistent with results from previous surveys assessing pharmacogenetics knowledge in pharmacists and doctors independently. A comprehensive review encompassing 12,430 pharmacists and pharmacy students across 26 countries found that, despite positive perceptions toward pharmacogenetics, there was a significant lack of adequate knowledge and confidence in this area. This aligns with your observation of pharmacists having high awareness but comparatively lower knowledge scores [22].

Also, research conducted among community pharmacists in the United Arab Emirates revealed that less than one-third possessed sufficient knowledge about pharmacogenetics testing, and nearly half did not have a positive attitude toward it. This further supports the notion that high awareness does not necessarily equate to in-depth knowledge among pharmacists [23].

In contrast, other study reported no significant difference in pharmacogenetics knowledge scores between physicians and pharmacists, which contrasts with your finding of doctors having superior knowledge scores [1].

Attitudinal assessments further support these observations. A higher percentage of doctors (66%) than pharmacists (34%) believe that pharmacogenetic testing should be a routine part of patient care ($p = 0.01$). Similarly, more doctors (54%) than pharmacists (46%) agree that such testing improves patient outcomes. These trends persist across questions regarding the utility of pharmacogenomic testing in drug selection, administration routes, and reduction of adverse drug reactions, with doctors consistently expressing more favorable views. These findings align with existing literature. A systematic review indicated that pharmacists and pharmacy students generally have positive perceptions of pharmacogenomics but often lack sufficient knowledge and confidence for its practical application [22]. Another study found that primary care providers were more likely than specialists to view pharmacogenetic testing as useful, and educational interventions increased their comfort with ordering such tests [24].

The skepticism shared by both groups regarding the impact of pharmacogenetics testing on drug development costs (42% agreement from both) suggests a need for further education on the broader economic implications of personalized medicine.

The integration of pharmacogenetic testing into clinical practice presents several challenges, as evidenced by the data in Figure 1. Both pharmacists and doctors report significant barriers, with a notable convergence in their experiences. The primary obstacles identified include a lack of knowledge or awareness (100%), high costs or limited funding (94%), absence of testing devices (92%), and insufficient time (92%). These findings are consistent with existing literature, which highlights similar impediments to the adoption of pharmacogenetic testing.

A systematic review identified gaps in knowledge, data storage and security concerns, and legal and ethical issues as prominent challenges to the widespread implementation of pharmacogenomic [25]. Similarly, a study focusing on primary care practitioners highlighted costs, ethical considerations, and the lack of clinical guidelines as significant barriers [26]. These parallels suggest that the challenges observed in our study are not isolated but reflect broader systemic issues within the healthcare community.

The lack of clinical guidelines (86%) and policy or administrative barriers (74%) further complicate the implementation process. The absence of standardized protocols can lead to uncertainty and variability in testing practices, as noted in previous research [27]. Additionally, administrative hurdles can deter healthcare providers from incorporating pharmacogenetic testing into routine care.

Interestingly, the shortage of qualified staff was reported by a smaller proportion of respondents (43%), suggesting that while staffing is a concern, it may not be as critical as other factors. This finding aligns with studies that emphasize the need for specialized training and education over mere staffing numbers [28].

Additionally, cultural factors and societal beliefs may influence the acceptance of pharmacogenomic interventions. In several regions, including Nigeria and Egypt, ethical concerns regarding genetic data privacy have been raised, leading to hesitation among both healthcare professionals and patients [2,10].

Addressing these challenges requires a multifaceted approach. Educational initiatives aimed at enhancing the knowledge base of both pharmacists and doctors are essential. Developing and disseminating clear clinical guidelines can provide a framework for consistent practice. Moreover, policy reforms to reduce administrative barriers and financial strategies to offset testing costs could facilitate broader adoption of pharmacogenetic testing.

- **Study limitations**

This study has several potential limitations. First, the sample size of 250 participants may not fully represent the broader population of pharmacists and doctors in Iraq. Second, our survey was conducted among pharmacists and doctors in only three hospitals in Karbala and Najaf, limiting its generalizability to the entire country. Third, there is a lack of sufficient local and regional research on this topic, making comparisons with other studies challenging.

5. Conclusion

The significant contrast between awareness and knowledge of pharmacogenetic testing among pharmacists and doctors underscores the necessity for targeted educational initiatives. Enhancing training programs to address the specific needs of each profession is vital for the successful implementation of pharmacogenetics in clinical settings. Interdisciplinary collaboration and continuous professional development will play key roles in optimizing personalized patient care through the informed application of pharmacogenetic insights.

By addressing these educational gaps and fostering a collaborative approach, healthcare systems can better harness the potential of pharmacogenetics to improve therapeutic outcomes and reduce adverse drug reactions.

6. Recommendations

- Further trials with larger sample sizes, including participants from all cities in Iraq, are necessary. Additionally, surveys should be conducted among other healthcare professionals—such as nurses, genetic counselors, academic professors—as well as the general public to gain a comprehensive understanding of pharmacogenetic awareness and its implications.
- Targeted Educational Programs should be developed for both professions, with a focus on pharmacogenomic applications, accessibility, and clinical decision-making.
- Integrating Pharmacogenetics into Clinical Practice through workshops, continuing education, and professional guidelines can improve implementation.
- Further Research & Comparisons with international studies could help determine whether similar knowledge gaps exist in other healthcare systems and guide improvements in pharmacogenetic education

7. Acknowledgement

The authors would like to thank Al Zahrawi College University, karbala, Iraq, for its support in the present work. The authors would like to extend heartfelt gratitude to all the participants of the study.

8. **Conflict of interest**: there is no conflict of interest.

9. **Ethical Approval:** It was obtained through the Ethical Board at Al Zahrawi College University (REBZ Ref No.10/2/2025).

10. References

1. Albassam A, Alshammari S, Ouda G, Koshy S, Awad A. Knowledge, perceptions and confidence of physicians and pharmacists towards pharmacogenetics practice in Kuwait. PloS one. 2018 Sep 5;13(9):e0203033.

2. Nagy M, Lynch M, Kamal S, Mohamed S, Hadad A, Abouelnaga S, Aquilante CL. Assessment of healthcare professionals' knowledge, attitudes, and perceived challenges of clinical pharmacogenetic testing in Egypt. Personalized Medicine. 2020 Jul 1;17(4):251-60.

3. AlEjielat R, Ejielat Z, Andrawes S, Mhaidat NM. An evaluation of the knowledge, opinions, expectations and concerns toward pharmacogenomics among Jordanian pharmacists. Personalized medicine. 2016 Mar 1;13(2):143-54.

4. Kudzi W, Addy BS, Dzudzor B. Knowledge of pharmacogenetics among healthcare professionals and faculty members of health training institutions in Ghana. Ghana medical journal. 2015;49(1):50-6.

5. Qahwaji R, Ashankyty I, Sannan NS, Hazzazi MS, Basabrain AA, Mobashir M. Pharmacogenomics: a genetic approach to drug development and therapy. Pharmaceuticals. 2024 Jul 13;17(7):940.

6. Abdela OA, Bhagavathula AS, Gebreyohannes EA, Tegegn HG. Ethiopian health care professionals' knowledge, attitude, and interests toward pharmacogenomics. Pharmacogenomics and personalized medicine. 2017 Dec 5:279-85.

7. Elewa H, Alkhiyami D, Alsahan D, Abdel-Aziz A. A survey on the awareness and attitude of pharmacists and doctors towards the application of pharmacogenomics and its challenges in Q Atar. Journal of Evaluation in Clinical Practice. 2015 Aug;21(4):703-9.

8. Bannur Z, Bahaman S, Salleh MZ, Teh LK. Pharmacogenomics based practice in Malaysia: the attitude, knowledge and adoption by the healthcare professionals. IIUM Medical Journal Malaysia. 2014 Jun 1;13(1).

9. Muzoriana N, Gavi S, Nembaware V, Dhoro M, Matimba A. Knowledge, attitude, and perceptions of pharmacists and pharmacy students towards pharmacogenomics in Zimbabwe. Pharmacy. 2017 Jun 30;5(3):36.

10. Enato EF. Perceptions of health care professionals towards pharmacogenomics in Nigeria: preliminary results. West Afr J Pharm. 2011;22(1):97-101.

11. Moen M, Lamba J. Assessment of Healthcare Students 'Views on Pharmacogenomics at the University of Minnesota. Pharmacogenomics. 2012 Oct 1;13(13):1537-45.

12. Wang L. Pharmacogenomics: a systems approach. Wiley Interdisciplinary Reviews: Systems Biology and Medicine. 2010 Jan;2(1):3-22.

13. Shobana N, Rithusha V, Raja s, *et al* . Cross-Sectional Survey on Pharmacogenomics Knowledge, Attitudes, and Perceptions Among Medical and Pharmacy Students. (2024). *African Journal of Biomedical Research*, *27*(3S), 3806-3816.

14. Ausi Y, Barliana MI, Postma MJ, Suwantika AA. One step ahead in realizing pharmacogenetics in low-and middle-income countries: what should we do?. Journal of multidisciplinary healthcare. 2024 Dec 31:4863-74.

15. Pearce A, Terrill B, Alffenaar JW, Patanwala AE, Kummerfeld S, Day R, Young MA, Stocker SL. Pharmacogenomic testing: Perception of clinical utility, enablers and barriers to adoption in Australian hospitals. Internal Medicine Journal. 2022 Jul;52(7):1135-43.

16. Krebs K, Milani L. Translating pharmacogenomics into clinical decisions: do not let the perfect be the enemy of the good. Human genomics. 2019 Dec;13:1-3.

17. McCullough KB, Formea CM, Berg KD, Burzynski JA, Cunningham JL, Ou NN, Rudis MI, Stollings JL, Nicholson WT. Assessment of the pharmacogenomics educational needs of pharmacists. American journal of pharmaceutical education. 2011 Apr 11;75(3):51.

18. McMahon T, Tucci J. The perceptions of pharmacists in Victoria, Australia on pharmacogenetics and its implications. Pharmacy Practice (Internet). 2011 Sep;9(3):141-7.

19. Stanek, E. J., Sanders, C. L., Taber, K. A., et al. (2012) Adoption of pharmacogenomic testing by US physicians: results of a nationwide survey. Clinical Pharmacology and Therapeutics, 91 (3), 450–458.

20. Tamaoki, M., Gushima, H. & Tsutani, K. (2007) Awareness survey of parties involved in pharmacogenomics in Japan. Pharmacogenomics, 8 (3), 275–286. [Comparative Study].

21. Mosch R, van der Lee M, Guchelaar HJ, Swen JJ. Pharmacogenetic panel testing: a review of current practice and potential for clinical implementation. Annual Review of Pharmacology and Toxicology. 2025;65.

22. Wondrasek A, Fryza A, Aziz MA, Leong C, Kowalec K, Maruf AA. Knowledge, perceptions, and attitudes toward pharmacogenomics among pharmacists and pharmacy students: a systematic review. Health Science Reports. 2024 Jan;7(1):e1844.

23. Ramadan A, Jarab AS, Al Meslamani AZ. Investigation of community pharmacists' knowledge and attitudes of pharmacogenomics testing: implication for improved pharmacogenomic testing practice. Human Genomics. 2024 Jan 30;18(1):8.

24. Preys CL, Blout Zawatsky CL, Massmann A, Heukelom JV, Green RC, Hajek C, Hickingbotham MR, Zoltick ES, Schultz A, Christensen KD. Attitudes about pharmacogenomic testing vary by healthcare specialty. Pharmacogenomics. 2023 Jul 1;24(10):539-49.

25. Youssef E, Bhattacharya D, Sharma R, Wright DJ. A theory-informed systematic review of barriers and enablers to implementing multi-drug pharmacogenomic testing. Journal of Personalized Medicine. 2022 Nov 2;12(11):1821.

26. Frigon MP, Blackburn MÈ, Dubois-Bouchard C, Gagnon AL, Tardif S, Tremblay K. Pharmacogenetic testing in primary care practice: opinions of physicians, pharmacists and patients. Pharmacogenomics. 2019 Jun 1;20(8):589-98.

27. Abou Diwan E, Zeitoun RI, Abou Haidar L, Cascorbi I, Khoueiry Zgheib N. Implementation and obstacles of pharmacogenetics in clinical practice: an international survey. British Journal of Clinical Pharmacology. 2019 Sep;85(9):2076-88.

28. Salas-Hernández A, Galleguillos M, Carrasco M, López-Cortés A, Redal MA, Fonseca-Mendoza D, *et al* . An updated examination of the perception of barriers for pharmacogenomics implementation and the usefulness of drug/gene pairs in Latin America and the Caribbean. Frontiers in pharmacology. 2023 May 11;14:1175737.