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Empowering precision medicine: Insights from a national survey on pharmacogenomics knowledge, attitudes, and perceptions among community pharmacists in the UAE

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ABSTRACT

Background: Community pharmacists are essential to pharmacogenomics implementation because they can help trainers, clinical advisors, and other medical professionals understand the importance of pharmacogenomics and encourage them to use it in their practice. This study is to evaluate the community pharmacists' understanding, attitudes, and perceptions of pharmacogenomics in the United Arab Emirates (UAE).

Methods: Professionals employed at community pharmacies in Abu Dhabi, Dubai, and the Northern Emirates participated in a cross-sectional study design. From July 2023 to February 2024, five pharmacy students in their last year conducted the survey. The study team employed a structured questionnaire to collect data in addition to conducting in-person interviews. The study questionnaire comprised three distinct sections namely, demographic information, knowledge of pharmacogenomics concepts, and perceptions regarding pharmacogenomics.

Results: A total of 586 pharmacists enrolled in the study. The average knowledge score regarding pharmacogenomics was 75.1 % with a 95 % confidence interval (CI) of [72.4 %, 77.7 %]. The average attitude score toward pharmacogenomics was 67.5 % with a 95 % CI of [66.3 %, 68.7 %]. Better pharmacogenomics knowledge among several groups: independent pharmacies (OR 1.7; 95 % CI 1.2–2.4), Pharmacists in Charge (OR 1.4; 95 % CI 1.3–2.02), pharmacists with 11–15 years of experience (OR 2.1; 95 % CI 1.4–4.2), graduates from international universities (OR 4.6; 95 % CI 1.6–12.9), and those who received training on pharmacogenomics (OR 11.9; 95 % CI 3.3–14.5). Similarly, better attitude scores were observed among independent pharmacies (OR 1.5; 95 % CI 1.1–2.1), Pharmacists in Charge (OR 1.5; 95 % CI 1.07–2.1), pharmacists with 16–20 years of experience (OR 2.1; 95 % CI 1.16–3.7), graduates regional universities (OR 1.47; 95 % CI 1.05–2.1), and those who received training on pharmacogenomics (OR 4.8; 95 % CI 3.2–7.3).

Conclusion: The positive attitudes toward pharmacogenomics that we found in our research indicate that community pharmacists in the United Arab Emirates are beginning to realize the potential advantages of pharmacogenomics in terms of improving patient care. Policies ensuring the privacy and confidentiality of genetic information are also necessary in considering concerns about the availability of genetic test results to insurance companies and potential employers.

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1. Introduction

Pharmacogenomics is a subfield of pharmacology that examines how genetic variations affect a drug's toxicity or efficacy and helps medical practitioners predict a patient's response to treatment.[1] Moreover, it holds promise for optimizing drug dosage and limiting the occurrence of adverse drug reactions.[2,3] With the evolution of the Human Genome Project and the emergence of pharmacogenomics and pharmacogenetics, there are significant expectations regarding the transformative potential of genetic information to improve medicine by enhancing the predictability of side effects and enabling the screening of patients for undesired drug side effects.[4] While healthcare is continuously improving, the use of pharmacogenomics is rapidly growing, adjusting medicine according to the genetic map of individuals.[5] However, healthcare professionals' insufficient knowledge and awareness of genomics acted as a barrier to clinical application.[6] Unfortunately, most of the drugs incorporated by the Food and Drug Administration (US-FDA) have a narrow therapeutic index and potential for toxicity.[7–10]

Among other specialists in interdisciplinary teams, community pharmacists play a key role in implementing pharmacogenomics. Consequently, they should have appreciable knowledge of pharmacology and pharmacotherapy that should enable them to convey the practical dynamics of pharmacogenomics to other staff and healthcare professionals (HCPs), including trainers, clinical advisors, and medical professionals. As a result, guiding these other key HCPs on how to apply pharmacogenomics in their practice.[6,11]

It could be argued that pharmacists who are familiar with pharmacogenomics do positively enhance treatment selection, providing patient counseling, and implementing genetic testing to enhance treatment outcomes.[12,13] Furthermore, a systematic review conducted in the USA, illustrated that community pharmacists show a positive attitude toward pharmacogenomics, regardless of their level of knowledge about pharmacogenomics.[6] In comparison, a study conducted in Victoria, Australia, in 2011 has shown that pharmacists lack sufficient knowledge about pharmacogenomics. This could explain why most pharmacists in the same study don't feel confident enough to advise patients about pharmacogenetics testing.[12] Whereas in the Middle East, a study performed in Qatar showed that doctors and pharmacists lack information about the practical implementation of pharmacogenomics. In comparison to physicians, pharmacists exhibited a more favorable attitude toward the application of pharmacogenomics in daily medical practice.[14] With low to moderate levels of pharmacogenomics knowledge, the majority were aware of the importance of gaining more knowledge about pharmacogenomics.[15]

Community pharmacists play an essential role in counseling patients about the appropriate use of their medications, which incorporates the implementation of pharmacogenomics to make the process more accurate and personalized for each patient. Notably, the knowledge, attitudes, and perceptions of pharmacogenomics among community pharmacists have not been studied yet in the United Arab Emirates (UAE); consequentially, in this study, we are aiming to fill this knowledge gap by addressing the knowledge, attitudes, and perception gaps that will aid in developing the potential for pharmacogenomics training for undergraduate and postgraduate pharmacy students.

2. Methods and materials

2.1. Study design and setting

The objective of this cross-sectional study was to assess the understanding and perspectives of pharmacogenomics among community pharmacists in the United Arab Emirates (UAE). A wide variety of medical services are offered by both the public and private sectors in the United Arab Emirates (UAE), which boasts a highly developed healthcare system. Community pharmacies play a crucial role in this system by providing accessible locations for medication distribution, patient counseling, and public health education. This study was conducted in Abu Dhabi, Dubai, and the Northern Emirates, three key regions within the UAE. These locations were chosen to ensure a representative sample of the UAE's diverse population. Additionally, variations in pharmacy practice across different regions were considered. Abu Dhabi and Dubai, with their significant healthcare infrastructure and high density of community pharmacies, are the two major emirates in the UAE. The Northern Emirates, offering both urban and rural settings, provides a unique environment for those interested in understanding the diverse community pharmacy practices in the UAE. To achieve this goal, a survey was conducted among professionals working in community pharmacies across Abu Dhabi, Dubai, and the Northern Emirates. The survey was administered by five pharmacy students in their final year, spanning from July 2023 to February 2024.

Before conducting the in-person interviews, the student researchers underwent comprehensive training on utilizing the questionnaire and familiarizing themselves with the scientific terminology utilized in the study. This proactive approach was informed by previous experiences, which underscored the significance of thorough preparation in enhancing interviewer proficiency and minimizing survey-related errors.

2.2. Research instrument development, including pilot testing

A comprehensive review of existing literature[2,16,17] laid the foundation for the development of a structured questionnaire, which was tailored to suit the unique environment of the United Arab Emirates (UAE) while addressing key research objectives. To ensure the questionnaire's appropriateness and applicability, consultation with experts in the field of pharmacy practice was undertaken. Additionally, feedback on the questionnaire's design and relevance was sought from five faculty members of the Ajman University Faculty of Medicine and Clinical Pharmacy. Subsequent to incorporating minor revisions based on expert input, including clarification of scientific terms, adjustments to page and question numbering, and refinement of question interconnections, the questionnaire underwent validation using Lawshe's content validity approach.[18]

According to Lawshe's method,[19] items failing to meet the established cutoff point were eliminated, while those with a content validity ratio (CVR) exceeding 0.78 were deemed acceptable. Notably, each item in the survey surpassed the CVR threshold of 0.78, indicating satisfactory validity. The content validity index (CVI) of the finalized research instrument was computed by averaging the CVR values of items deemed acceptable, yielding an overall CVI value of 0.851,[20] signifying comprehensive content validity.

Subsequently, the face validity of the questionnaire was evaluated through a pilot study conducted from July 10 to July 16, 2023. A convenient sample of fifty community pharmacists participated in the pilot study, with their data ultimately excluded from the final analysis. Among them, forty participants completed the questionnaire. Utilizing the findings of the pilot study, an assessment of the questionnaire's reliability and a determination of the main research sample size for the principal investigation were conducted. Internal consistency of the questionnaire was evaluated using Cronbach's α, yielding a satisfactory result of 0.76, indicating adequate reliability.

2.3. Research instrument sections

The study questionnaire comprised three distinct sections:

- Part 1: This section encompassed six questions aimed at gathering demographic information from the respondents. It included inquiries regarding gender, years of professional experience, attendance of pharmacogenomics training, and the respondent's role within the pharmacy setting, such as chief pharmacist or pharmacist in charge.

- Part 2: Comprising six questions, this section was tailored to assess the respondents' knowledge and comprehension of pharmacogenomics concepts. These questions were specifically crafted to evaluate the depth of understanding regarding pharmacogenomics principles and applications.
- Part 3: Consisting of twelve questions, this section delved into the respondents' perceptions regarding pharmacogenomics. These questions were designed to capture the respondents' attitudes, beliefs, and opinions regarding the integration and implications of pharmacogenomics within their professional practice and the broader healthcare landscape.

2.4. Questionnaire scoring

To assess respondents' awareness of pharmacogenomics concepts, categorical responses (i.e., Yes, No, Do Not Know) were utilized. Each response was graded as 'correct' or 'incorrect' based on its alignment with the subject matter. Correct responses received one point, while incorrect responses received zero points. Raw scores for each respondent were calculated by summing the results for all six items.

Similarly, a 5-point Likert scale was employed to measure respondents' agreement with 12 positive statements about pharmacogenomics, ranging from strongly disagreeing (0) to strongly agreeing (4). The maximum score attainable was 40, obtained by summing the raw scores for each respondent across the 12 statements.

To categorize respondents' scores as indicative of "good knowledge" or "positive attitude," median scores were determined for each category. A median knowledge score of six was established, designating respondents with a score of at least six as possessing good knowledge. Those with scores below six were considered to have knowledge gaps. Likewise, a median attitude score of 33 was determined, classifying respondents with a score of at least 33 as having a positive attitude. Respondents with scores below 33 were classified as having a negative attitude.

2.5. Sample size calculation and target population

The main study's sample size was determined based on the findings of the pilot study, where the overall response rate was 80 %. Utilizing the data obtained from the query "Do you have previous experience with pharmacogenomics?" revealed that approximately 45 % of participants responded affirmatively.

With an alpha level of 5 % and a desired 95 % confidence interval (CI), a precision (D) setting of 5 % indicated a maximum width for the 95 % CI of 10 %. Based on these parameters and assuming a non-response rate of around 30 %, it was determined that a sample size of 544 respondents would be adequate.

Specific criteria were applied in selecting the study sample for the primary investigation. Eligible participants included community pharmacists with a minimum of three months of professional experience, employed either in independent pharmacies or within chains registered with regulatory bodies such as the Ministry of Health, the Health Authority Abu Dhabi (HAAD), or the Dubai Health Authority. Exclusion criteria encompassed individuals with less than three months of professional experience, such as newly qualified pharmacists or those still in a probationary period, as well as individuals not registered with any of the aforementioned authorities.

2.6. Sampling technique

To ensure the study's representativeness, random sampling was utilized. With approximately 1300 licensed community pharmacists in the UAE's private sector[21,22] and an estimated 2000 community pharmacies engaged in professional activities according to a 2010 survey,[23] we aimed to create a sample that accurately reflected this distribution.

The locations and contact details of community pharmacies within the research areas were obtained from local business directories and the Yellow Pages. These pharmacies were then stratified based on their locations, resulting in three distinct strata: community pharmacies in Dubai, community pharmacies in Abu Dhabi, and community pharmacies in the Northern Emirates.

Subsequently, a sample frame was established using an Excel spreadsheet, documenting essential information such as each pharmacy's name, location, type, phone number, and email address. Each pharmacy was assigned a unique ID number, and a total of 544 community pharmacies were randomly selected from this sample frame using a simple random sampling technique.

Following the selection process, the chosen community pharmacies were organized based on their type and location, ensuring a balanced representation across different regions and types of pharmacies within the UAE.

2.7. Data collection

From July 22, 2023, to February 26, 2024, the research team visited selected community pharmacies across Abu Dhabi, Dubai, and the Northern Emirates. Pharmacists were briefed on the research's objectives and asked to provide their email addresses for further communication. Subsequently, utilizing a prepared questionnaire as a reference, seasoned researchers conducted in-person interviews to gather data.

2.8. Statistical analysis

The gathered data were analyzed using SPSS Version 26. Continuous normally distributed quantitative variables were expressed as mean ± standard deviation (±SD), while categorical quantitative variables were presented as frequencies (percentages). For continuously skewed data, the interquartile range (IQR) and median were utilized for summarization.

To assess differences between groups' quantitative variables, one-way ANOVA, non-parametric versions, and unpaired student *t*-tests were applied when appropriate. Factors influencing respondents' attitudes and knowledge of pharmacogenomics were identified using multivariate logistic regression models. Statistical significance was assumed for *p*-values less than 0.05.

2.9. Ethical considerations

This study received approval from the Ajman University Institutional Ethical Review Committee (P-H-S-2023-2-9). Prior to data collection, participants were informed about the study's objectives and assured that their participation was voluntary. Written informed consent was obtained from each participant, indicating their full agreement to complete and submit the questionnaire. Participant confidentiality was maintained, and their identities were not recorded during the study.

3. Results

3.1. Demographic characteristics of the participants

Table 1 displays the demographic characteristics of the study participants. A total of 586 pharmacists enrolled in the study. Most participants were Pharmacists in Charge (63.3 %), with one-third being Chief Pharmacists (36.7 %).

3.2. Knowledge and attitude of community pharmacists on Pharmacogenomics

The average knowledge score regarding pharmacogenomics was 75.1 % with a 95 % confidence interval (CI) of [72.4 %, 77.7 %]. The average attitude score toward pharmacogenomics was 67.5 % with a 95 % CI of [66.3 %, 68.7 %].

Table 1
Demographic information of the pharmacists ($n = 586$).

Demographics	Response	Frequency	Percentage
Gender	Male	180	30.7
	Female	406	69.3
Years of experience	1–5 Years	65	11.1
	6–10 Years	215	36.7
	11–15 Years	67	11.4
	16–20 Years	153	26.1
	> 20 Years	86	14.7
Pharmacy type	Independent Pharmacy	306	52.2
	Chain Pharmacy	280	47.8
Pharmacist position	Pharmacist in charge	371	63.3
	Chief pharmacist	215	36.7
Graduation university	Local	215	36.7
	Regional	346	59
	International	25	4.3
Received a training on Pharmacogenomics	Yes	176	30
	No	410	70

Table 2 compares knowledge and attitude scores across demographics, revealing statistically significant associations. Males demonstrated better knowledge scores than females (80.9 % vs 72.4 %; $p = 0.004$), while Independent Pharmacies showed better knowledge than chain pharmacies (78.3 % vs 71.4 %; $p = 0.01$). Participants from international and regional universities scored higher than those from local universities (90.6 % vs 75.8 % vs 72 %; $p = 0.02$), and individuals trained in pharmacogenomics had significantly better knowledge (99.1 % vs 64.7 %; $p < 0.001$).

Similarly, better attitude scores were observed among males compared to females (69.8 % vs 66.4 %; $p = 0.008$), among independent pharmacies compared to chain pharmacies (69.3 % vs 66.4 %; $p = 0.001$), among Pharmacists in Charge compared to Chief Pharmacists (68.7 % vs 65.3 %; $p = 0.006$), among participants who graduated from international and regional universities compared to those from local universities (73.3 % vs 68.3 % vs 65.3 %; $p = 0.007$), and among those who received training on pharmacogenomics (76.3 % vs 63.6 %; $p < 0.001$). Additionally, participants with more years of experience had better attitude scores compared to those with fewer years of experience ($p = 0.005$).

The results of each question related to knowledge and attitude about pharmacogenomics were shown in Tables 3 & 4 respectively.

3.3. Factors influencing knowledge and attitude on pharmacogenomics

Table 5 displays the results of the multivariate logistic regression

Table 3
Number and percentage of the questions on knowledge of pharmacogenomics ($n = 586$).

Knowledge items	Yes		No		Don't know	
	F	%	F	%	F	%
Genetic alterations can lead to adverse reactions.	474	80.9	85	14.5	27	4.6
There are 46 chromosomes in the human genome.	473	80.7	79	13.5	34	5.8
The FDA asserts that pharmacogenomics testing should be performed for several medications.	440	75.1	95	16.2	51	8.7
Environmental factors like nicotine smoke can influence gene expression.	423	72.2	105	17.9	58	9.9
Genetic variations in patients can affect the efficacy of certain drugs.	416	71	105	17.9	65	11.1
Each cell in the body harbors the complete genome.	413	70.5	111	18.9	62	10.6

Abbreviations: F, frequency; %, Percentage.

Table 2
Comparing knowledge and attitude scores according to demographics.

Demographics	Knowledge score (6 items)				Attitude score (12 items)			
	Mean	95 % CI		P-value	Mean	95 % CI		*P*-value
Gender								
Male	80.92	76.65	85.20	**0.004***	69.86	67.55	72.16	**0.008***
Female	72.45	69.16	75.74		66.44	65.09	67.78	
Pharmacy type								
Independent Pharmacy	78.37	74.78	81.97	**0.010***	69.35	67.77	70.94	**0.001***
Chain Pharmacy	71.42	67.56	75.29		65.45	63.72	67.17	
Position in the Pharmacy								
Pharmacist in charge	76.81	73.51	80.12	0.085	68.72	67.27	70.16	**0.006***
Chief pharmacist	72.01	67.61	76.41		65.36	63.37	67.36	
Experiences								
1–5 Years	73.07	65.29	80.86	0.057	64.16	60.85	67.47	**0.005***
6–10 Years	70.93	66.45	75.40		65.84	63.82	67.86	
11–15 Years	82.33	75.44	89.23		66.72	63.34	70.11	
16–20 Years	75.38	70.04	80.71		69.53	67.45	71.62	
> 20 Years	80.62	73.77	87.46		71.07	67.69	74.45	
Graduation university								
Local	72.02	67.61	76.41	**0.020***	65.36	63.37	67.36	**0.007***
Regional	75.81	72.36	79.27		68.38	66.92	69.85	
International	90.66	80.92	100.4		73.33	66.04	80.62	
Trained on Pharmacogenomics								
Yes	99.14	98.60	99.69	**<0.001***	76.32	74.65	77.99	**<0.001***
No	64.71	61.42	68.01		63.69	62.33	65.06	

Notes: *P-values <0.05 considered statistically significant, P-values obtained from independent t-test and One Way ANOVA.

Table 4
Number and percentage of questions on attitude about pharmacogenomics.

Attitude items	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	F	%	F	%	F	%	F	%	F	%
I am considering obtaining a genetic test in the future to assess my susceptibility to specific inherited conditions.	22	3.8	72	12.3	84	14.3	318	54.3	90	15.4
Attending a genetics (PGX) conference or course is something I would be interested in.	8	1.4	52	8.9	119	20.3	271	46.2	136	23.2
Community pharmacists should provide education to patients about genomic reports, in addition to physicians.	13	2.2	69	11.8	89	15.2	258	44	157	26.8
Community pharmacists are capable of interpreting genomic reports.	34	5.8	55	9.4	96	16.4	245	41.8	156	26.6
I am interested in participating in a biobank to store my genetic material.	24	4.1	75	12.8	118	20.1	242	41.3	127	21.7
If there is a family history of diabetes, I would contemplate undergoing genetic testing to help select a medication with minimal side effects.	43	7.3	127	21.7	111	18.9	241	41.1	64	10.9
My primary interest lies in understanding my predisposition to diseases for which preventive measures currently exist.	32	5.5	108	18.4	114	19.5	240	41	92	15.7
I am interested in contributing to genetic research.	47	8	86	14.7	133	22.7	222	37.9	98	16.7
I am concerned about the availability of genetic test results to insurance companies and potential employers.	7	1.2	45	7.7	89	15.2	215	36.7	230	39.2
If diagnosed with cancer, I would consider using genetic testing to guide treatment decisions and minimize side effects.	38	6.5	143	24.4	169	28.8	203	34.6	33	5.6
I appreciate the convenience of ordering genetic tests online.	4	0.7	26	4.4	69	11.8	189	32.3	298	50.9
I am pleased that genetic testing is now available to assess the risk of major genetic disorders, especially in cases where there is a family history of the condition.	11	1.9	32	5.5	73	12.5	170	29	300	51.2

Abbreviations: F, frequency; %, Percentage.

Table 5
Regression analysis for the factors affecting knowledge and attitude on pharmacogenomics.

	Good knowledge ≥ 6				Positive attitude ≥ 33			
Demographics	OR	95 % CI		P-value	OR	95 % CI		P-value
Gender (Ref. Male)								
Female	0.733	0.515	1.044	0.085	0.775	0.544	1.105	0.159
Pharmacy type (Ref. Chain Pharmacy)								
Independent Pharmacy	1.748	1.260	2.425	**0.001***	1.579	1.139	2.189	**0.006***
Position in the Pharmacy (Ref. Chief pharmacist)								
Pharmacist in charge	1.447	1.033	2.028	**0.032***	1.505	1.074	2.109	**0.018***
Experiences (Ref. 1–5 Years)								
6–10 Years	0.852	0.488	1.486	0.573	1.261	0.721	2.206	0.416
11–15 Years	2.098	1.041	4.229	**0.038***	1.535	0.772	3.050	0.222
16–20 Years	1.267	0.708	2.265	0.425	2.105	1.168	3.794	**0.013***
> 20 Years	1.761	0.917	3.383	0.089	1.835	0.957	3.521	0.068
Graduation university (Ref. Local)								
Regional	1.346	0.957	1.894	0.088	1.475	1.048	2.076	**0.026***
International	4.687	1.697	12.946	**0.003***	2.007	0.850	4.739	0.112
Training on Pharmacogenomics (Ref. No)								
Yes	11.976	3.336	14.563	**<0.001***	4.877	3.240	7.340	**<0.001***

Notes: *P-values <0.05 considered statistically significant.
Good knowledge and Positive scores were generated by finding the median score.

analysis for factors associated with knowledge and attitude about pharmacogenomics. The analysis revealed better pharmacogenomics knowledge among several groups: independent pharmacies (OR 1.7; 95 % CI 1.2–2.4), Pharmacists in Charge (OR 1.4; 95 % CI 1.3–2.02), pharmacists with 11–15 years of experience (OR 2.1; 95 % CI 1.4–4.2), graduates from international universities (OR 4.6; 95 % CI 1.6–12.9), and those who received training on pharmacogenomics (OR 11.9; 95 % CI 3.3–14.5).

Similarly, better attitude scores were observed among independent pharmacies (OR 1.5; 95 % CI 1.1–2.1), Pharmacists in Charge (OR 1.5; 95 % CI 1.07–2.1), pharmacists with 16-20 years of experience (OR 2.1; 95 % CI 1.16–3.7), graduates regional universities (OR 1.47; 95 % CI 1.05–2.1), and those who received training on pharmacogenomics (OR 4.8; 95 % CI 3.2–7.3).

4. Discussion

The current study provides valuable insights into the pharmacogenomics knowledge, attitudes, and perceptions among community pharmacists in the United Arab Emirates (UAE). The findings reveal a moderate level of understanding of pharmacogenomics concepts among the participants, with an average knowledge score of 75.1 %. Similarly, the average attitude score toward pharmacogenomics was 67.5 %, indicating a generally positive disposition toward the integration of pharmacogenomics into pharmacy practice. Our results were distinct from previous studies conducted in Nigeria, Syria, and Qatar,[14,24,25] yet

similar to those reported in Saudi Arabia,[13] where educational backgrounds were similar. These findings provide valuable insights into the current state of pharmacogenomics awareness and perceptions among community pharmacists in the UAE, highlighting areas for targeted interventions and educational initiatives to enhance pharmacists' role in personalized medicine.

The analysis of knowledge and attitude scores unveiled several noteworthy associations with demographic factors. Males exhibited higher knowledge and attitude scores compared to females, suggesting a potential gender disparity in pharmacogenomics education or awareness. This result is consistent with a previous study conducted in Qatar.[14] Another study in Jordan showed no difference between the 2 genders.[26] Pharmacists working in independent pharmacies demonstrated superior scores in both knowledge and attitude compared to those in chain pharmacies. This difference may be attributed to the characteristics of independent pharmacies, which often offer pharmacists more significant opportunities for education, professional growth, and autonomy. In contrast, pharmacists in chain pharmacies may have limited exposure to specific knowledge areas, such as pharmacogenomics, due to the more standardized operations of chain pharmacies.[27]

One of the most noteworthy findings is that pharmacists who graduated from universities in other countries had significantly higher knowledge scores than those who graduated from institutions within their own country or region. This discrepancy could be due to varying curricula and training standards across different countries. Institutions in countries with developed healthcare systems are likely to provide a more comprehensive and up-to-date education in pharmacogenomics. Additionally, exposure to diverse clinical practices and research environments abroad may enhance their understanding and application of pharmacogenomics.[28]

Additionally, participants with higher levels of education and those who received training in pharmacogenomics displayed significantly higher knowledge and attitude scores. These findings underscore the importance of targeted education and training initiatives in enhancing pharmacists' competency and positive attitudes toward pharmacogenomics.

Many international universities integrate pharmacogenomics into their core pharmacy curricula, providing students with in-depth theoretical knowledge and practical skills. Countries such as the United States, Canada, and several European nations are renowned for their excellent pharmacogenomics education and training programs.[29–32] Pharmacists trained abroad may have greater access to cutting-edge research and clinical applications of pharmacogenomics, significantly enhancing their understanding and practical use of the field. These countries frequently incorporate pharmacogenomics into clinical decision-making and personalized medicine, offering pharmacists practical experience that might be lacking for graduates from local or regional schools.[33]

Additionally, foreign-trained pharmacists often have more opportunities for continuing education and professional growth in pharmacogenomics. Nations with advanced healthcare systems typically host numerous workshops, seminars, and conferences dedicated to pharmacogenomics, contributing to the higher levels of knowledge observed in our study.[34,35]

Our research underscores the urgent need for more education and training in pharmacogenomics for community pharmacists in the United Arab Emirates. Several strategies could bridge this knowledge gap. First, it is crucial to integrate comprehensive pharmacogenomics modules into the curricula of local and regional pharmacy programs, covering fundamental principles, clinical applications, and ethical considerations.[35,36]

Additionally, designing and promoting continuing education programs focused on pharmacogenomics is essential to ensure that practicing pharmacists stay current with the latest advancements. These programs might include workshops, online courses, and certification programs. Establishing partnerships with international universities and healthcare institutions can expose local pharmacists to global best practices in pharmacogenomics, facilitating knowledge exchange and collaborative training initiatives such as exchange programs, joint research projects, and virtual seminars. Finally, advocating for policies that support the integration of pharmacogenomics into routine pharmacy practice is vital. These policies should include provisions for reimbursement of pharmacogenomics consultations, protection of patient privacy, and assurance of availability.[37]

The findings of various studies conducted worldwide consistently underscore the favorable attitude healthcare professionals hold toward pharmacogenomics (PG) and its potential to enhance the quality of healthcare services. Notable examples are from Jordan, the USA, and Canada.[2,26,38] Our study further strengthens this perspective, aligning with previous research and affirming the positive attitude healthcare professionals maintain toward the incorporation of pharmacogenomics into clinical practice.

Our study manifests a few limitations. Firstly, our study relied on self-reported data, which introduces the potential for recall bias and social desirability bias. Participants may have provided responses they deemed socially acceptable or may not have accurately recalled certain information, leading to inaccuracies in the data.[39] Secondly, our study adopted a cross-sectional design, which limits our ability to establish causality or determine temporal relationships between variables. Longitudinal studies would provide a more comprehensive understanding of how pharmacogenomics knowledge and attitudes evolve among community pharmacists.[40] Additionally, while efforts were made to ensure a representative sample by employing random sampling techniques, the generalizability of our findings may be limited due to the specific context of the UAE healthcare system and the characteristics of our study sample. These limitations should be considered when interpreting the results and may serve as avenues for future research to address.[41]

Future research should explore longitudinal changes in pharmacists' knowledge and attitudes toward pharmacogenomics, qualitative aspects of pharmacists' experiences with pharmacogenomics in practice, and the impact of educational interventions on pharmacists' knowledge and attitudes. Collaboration between academia, healthcare institutions, and regulatory bodies is crucial to drive forward research and practice in pharmacogenomics in the UAE.

The future of precision medicine continues to face many challenges, including related expenses, ethical issues, the security of big data, merging different platforms to integrate data, and the lack of skilled personnel to handle algorithms and data.[42] Modern medicine is a huge advancement for humanity, and with any luck, it will shortly offer even more advantages for patients and carers.

5. Conclusion

The positive attitudes toward pharmacogenomics observed in our study suggest a growing recognition among community pharmacists in the UAE of the potential benefits of pharmacogenomics in optimizing patient care. Pharmacists expressed interest in participating in genetic testing, attending genetics conferences or courses, and providing education to patients about genomic reports. Furthermore, concerns about the availability of genetic test results to insurance companies and potential employers underscore the need for policies ensuring the privacy and confidentiality of genetic information. These attitudes reflect a willingness among pharmacists to engage with pharmacogenomics and contribute to its integration into routine pharmacy practice.

Consent for publication

All authors are agreed for publication of this manuscript in Exploratory Research in Clinical and Social Pharmacy.

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CRediT authorship contribution statement

Ammar Abdulrahman Jairoun: Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Sabaa Saleh Al-Hemyari:** Writing – review & editing, Visualization, Validation, Methodology, Investigation, Conceptualization. **Moyad Shahwan:** Writing – review & editing, Visualization, Supervision, Project administration, Data curation. **Mena Al-Ani:** Writing – review & editing, Writing – original draft, Validation, Software, Investigation. **Mustafa Aal Yaseen:** Writing – original draft, Resources. **Mahmood H. Al-Aawad:** Writing – original draft, Software, Resources. **Ghala Rashid Alnuaimi:** Writing – review & editing. **B. Mahalakshmi:** Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

Not applicable.

Declaration of competing interest

All authors declare that they have no conflict of interest.

Data availability

The original contributions presented in the study are included in the further inquiries can be directed to the corresponding authors.

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