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Original Research

Knowledge and Attitudes of the Healthcare Providers in the United Arab Emirates toward the Reports of the Pharmacogenomics in Cardiovascular Disease Randomized Clinical Implementation "EmHeart" study: A Cross sectional study

Zeina N. Al-Mahayri, Emad Masuadi, Mohammad Al-Saadi, Khalid AlMaamari, Omar Al Zaabi, Saoud Altamimi, Khalifa Al-Seiari, Nasser Al-Shamsi, Hajar Alktifan, Maryam Alktifan, Basma Beiram, Bassam R. Ali, Azhar T. Rahma

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Abstract

Introduction: The "EmHeart" study, a randomized multicenter clinical trial, was launched in 2021 to investigate the implementation of pharmacogenomics (PGx) in the UAE, with a focus on cardiovascular patients taking clopidogrel, warfarin, atorvastatin, and rosuvastatin. Despite their potential benefits, clinicians' reluctance to use PGx testing and their results in clinical practice warrants evaluation. The Diffusion of Innovations (DOI) theory and the Technology Acceptance Model (TAM) are used in this study to compare attitudes and knowledge among healthcare providers, identify useful and confusing report components, and assess healthcare practitioners' attitudes toward PGx reports. **Methods:** A cross-sectional study employing a validated questionnaire to explore physicians' and pharmacists' knowledge and attitudes in the UAE. Participant recruitment used the Shafafiya portal with random and convenience sampling approaches. For statistical analysis, the sample size was calculated using the Raosoft website. Data entry and analyses were performed using the statistical package IBM SPSS. The Abu Dhabi Health Research and Technology Ethical Committee provided ethical approval (reference DOH/CVDC/2020/1187). **Results:** The study included 264 participants, split roughly equally between males and females. Around 50% (131) were between the ages of 25 to 34 years old. Nearly one-third were physicians, and one-third had been practicing healthcare for less than five years. Only 32 (12.1%) were Emirati nationals with the rest being expatriate health care workers, and one-third of the participants had not heard of PGx tests before, and only 5% had ordered a PGx test for their patients. The participants' overall mean score of the attitude toward the PGx tests was 3.79 (95% CI: 3.74, 3.84). However, the overall mean knowledge score was 71.5 (95% CI: 68.2, 74.8). **Conclusions:** The findings suggest that direct experience with PGx reports significantly enhances knowledge and attitudes, whether in a real patient context or educational setting. We are, therefore, advocating for targeted educational initiatives and training programs in pharmacogenomics.

Keywords: Pharmacogenomics, pharmacists, physicians, The Diffusion of Innovations theory, Technology Acceptance Model, UAE

Zeina N. Al-Mahayri. Department of Biomedical Sciences, College of Health Sciences, Abu Dhabi University, Al-Ain, UAE.
Emad Masuadi. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Mohammad Al-Saadi. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Khalid AlMaamari. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Omar Al Zaabi. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Saoud Altamimi. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Khalifa Al-Seiari. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Nasser Al-Shamsi. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Hajar Alktifan. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Maryam Alktifan. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Basma Beiram. Tawam Hospital, Pharmacy Department, Alain, UAE; Department of Pharmacology & Therapeutics, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Bassam R. Ali. Department of Genetics and Genomics, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE.
Azhar T. Rahma*. Institute of Public Health, College of Medicine & Health Sciences, United Arab Emirates University, Al-Ain, UAE, Azhar.talal@uaeu.ac.ae

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INTRODUCTION

Pharmacogenomics (PGx) studies the interactions between genetics and drugs to optimize drug-based therapies for individuals using the individual's genetic makeup[1]. The goal of PGx has been the development of prediction models to improve efficacy and forecast debilitating adverse events in specific individuals and, more recently, across populations based on similarities in age, gender, or, more commonly, race or ethnicity, as contrasted with the rest of the population[2]. Using genetic tests to determine the ideal pharmaceutical therapy for a patient will improve drug efficacy, reduce possible adverse drug reactions, and help find the optimal drug dose[3]. Pharmacogenomic testing reports provide information about an individual's genetic profile that can be used to tailor drug therapy to their specific needs, but little is known about how physicians perceive and utilize these reports in clinical practice[4].

Studies have shown several barriers to adopting pharmacogenomic testing in clinical practice, including a lack of knowledge and education among healthcare workers[5–13], limited access to testing, and uncertainty about the clinical utility of PGx reports. However, evidence suggests that pharmacogenomic testing can improve patient outcomes, particularly in drug efficacy and safety, including in the United Arab Emirates (UAE)[14–18]. Therefore, applying the pharmacogenomic information requires understanding how genetic variations impact a drug's pharmacokinetic and pharmacodynamic properties and prevent adverse drug events[19]. However, understanding that there is a combined influence of factors such as age, gender, race, ethnicity, diet, pathophysiologic conditions, and current medication use, as well as their relationship to genetic variability, is crucial[20].

The Department of Health (DOH) in Abu Dhabi, UAE, has recently approved and published a pharmacogenomic guideline, which healthcare providers will use as guidance for pharmacogenomic test interpretation and intervention and as a tool for medication selection and dosing decisions[21]. Moreover, an implementational clinical study (EmHeart) was initiated to investigate the importance of implementing pharmacogenomics (PGx) in the clinic in the UAE. This multicentre, randomized clinical trial aimed to enrol about 1,500 patients with cardiovascular diseases taking one or more of the following four prescription drugs: rosuvastatin, atorvastatin, warfarin, or clopidogrel. In addition, the project aims to investigate the cost-effectiveness of this practice when it is implemented nationally and demonstrate the impact of PGx-testing on patient outcomes and the healthcare system[14]. Consequently, a specific PGx report was created for this study to disseminate the PGx results including a CPIC-based recommendations for the healthcare workers involved in the care of patients recruited for interventional arm of the study. Despite the potential benefits of pharmacogenomic testing, its introduction into clinical practice has been slow. One possible explanation is that physicians do not understand how to interpret and/or use pharmacogenomic reports. As a result, it is critical to investigate physicians' and pharmacists' attitudes toward pharmacogenomic reports to identify areas for improvement in their delivery and consequently utility by the clinicians.

This study aims to investigate the physicians' and pharmacists' perspectives on the EmHeart project's pharmacogenomic report and identify any barriers to its use in clinical practice. The design of this study is guided by the Technology Acceptance Model (TAM) [22]. and the Diffusion of Innovations (DOI) theory[20]. TAM emphasizes that perceived usefulness and ease of use influence new technology acceptance, whereas DOI theory states that adopting new innovations is influenced by the features of the innovation, the adopter, and the social system in which the innovation is implemented.

The literature has documented that the application of PGx in clinical practice has improved the efficacy of several drugs. As a result, this study's findings can be used to develop tailored instructional programs for physicians and pharmacists to improve their understanding and use of pharmacogenomic reports, resulting in more effective patient care.

MATERIALS AND METHODS

We undertook a cross-sectional study, employing a validated questionnaire, to explore the knowledge and attitudes of diverse sectors across the UAE. These sectors comprised professionals, including physicians, pharmacists, nurses, and various other medical fields working in the Abu Dhabi Emirate. We used both an online and printed survey (See supplementary). The survey consisted of close-ended questions and open-ended questions that assessed healthcare providers' knowledge and attitudes towards the pharmacogenomic report, their perceived usefulness, understanding, and suggestions for improvement. It was piloted among 16 healthcare personnel and international experts in the field of PGx.

Our sampling methodology combined sampling techniques such as random sampling, convenience sampling, and snowball sampling to recruit participants to ensure a representative participant pool, meeting our inclusion criteria. We accessed the online Shafafiya portal of the DOH, which contained a population frame for all the healthcare providers working in the UAE. The participants were contacted either by email or by site visit. We followed the online survey research Checklist for Reporting Results of Internet E-Surveys (CHERRIES)[23], upholding transparency throughout the study. The survey was administered between July and December 2023. Visits were made to outpatient pharmacies, clinics, and hospitals within the emirate of Abu-Dhabi. The healthcare professionals were personally requested to complete the questionnaire, with follow-ups conducted within an hour or, if necessary, the following day to collect the completed forms. This hands-on approach significantly improved the participation rate.

For statistical analysis, the sample size was calculated using the Raosoft website for cross-sectional studies (http://www.raosoft.com/samplesize.html), assuming P = 0.27 (27% is the prevalence reported in similar previous studies), and a margin of error of 0.05 and confidence level of 95%. The sample size was 299 healthcare workers. Accounting for an average

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response rate of 56–84% (reported in previous studies), the calculated sample size needed for this analysis was 444 healthcare workers.

This study was conducted in accordance with the Declaration of Helsinki. Participants were informed about the purpose of the study, their right to decline participation, and their right to withdraw from the study at any time without consequences. Data were kept confidential, and participant identities were protected. This study has been approved by the Abu Dhabi Health Research and Technology Committee IRB (DOH/CVDC/2022/728).

Data entry and analyses were performed using the statistical package IBM SPSS Statistics for Windows, Version 28.0. (Armonk, NY: IBM Corp). Numerical data were presented as mean, and standard deviation and categorical data were presented as frequencies and percentages. The general linear model assessed the factors associated with attitude and knowledge scores. The level of significance was set at 0.05.

RESULTS

The study included 264 participants, almost half of whom were females. Around 50% (131) were between 25 to 34 years old. Nearly one-third were physicians, and one-third had been practicing for less than five years. Only 32 (12.1%) were Emirati nationals, and three-quarters had a bachelor's degree. Around three-quarters of the participants worked in the private sector, and around 156 (59.1%) worked in Al-Ain City. Most of the participants (202, 77.1%) were working in facilities located in urban areas. (See Table 1).

Table 2 presents the participant's responses to the questions related to the pharmacogenomic test. One-third of the participants had not heard of pharmacogenomic tests before, and only 5% had ordered a pharmacogenomic test for their patients. Around 164 (62.1%) had never seen any lab report of genetic testing, and 217 (83.5%) had never seen any lab report of pharmacogenomic testing during their practice. Only 28 (10.6%) were very confident in the ability to explain pharmacogenomic results to the patients. Although 174 (65.9%) did not receive any training, the majority (234, 89%) expressed their willingness to receive training on pharmacogenomic test reports.

The participants' overall mean score of the attitude toward the pharmacogenomic tests was 3.79 (95% CI: 3.74, 3.84). However, the overall mean knowledge score was 71.5 (95% CI: 68.2, 74.8). Table 3 presents the linear regression analysis of factors

Table 1. Participants' demographics

		N	%
What is your gender?	Male	130	49.2
	Female	134	50.8
Age (in years)	18-24	14	5.3
	25-34	131	49.6
	35-44	55	20.8
	45-54	51	19.3
	55+	13	4.9
How many years have you been practicing?	less than 5 years	91	34.5
	5 to 10 years	73	27.7
	11 to 15 years	37	14
	More than 15 years	63	23.9
Emiratis and other	Emiratis	32	12.1
	Expatriates	232	87.9
Degree	Bachelor	200	75.8
	Master	51	19.3
	PhD	13	4.9
Your facility is operated by	Government	59	22.3
	Private	205	77.7
Location of your facility	Abu Dhabi	108	40.9
	Al-Ain	156	59.1
Your occupation	Physician	92	34.8
	Pharmacist	172	65.2
Location of Facility	Rural	60	22.9
	Urban	202	77.1

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Table 2. Distribution of participants' responses to survey questions

Question	Answer	N	%
Have you heard of the term pharmacogenomics before?	Yes	170	64.4
	No	94	35.6
Have you ever ordered a pharmacogenomic test for one of your patients?	Yes	13	4.9
	No	251	95.1
Have you ever encountered a lab report of genetic testing during your practice?	Yes, I have seen a real patient genetic testing report.	72	27.3
	No, never seen any.	164	62.1
	I have seen a genetic testing report, but it was not for a real patient (e.g. on the internet or during an educational activity)	28	10.6
Have you ever encountered a lab report of a pharmacogenomic test during your practice?	Yes, I have seen a real patient pharmacogenomic testing report.	17	6.5
	No, never seen any.	217	83.5
	I have seen a pharmacogenomic testing report, but it was not for a real patient (e.g. on the internet or during an education)	26	10
How confident are you in your ability to explain pharmacogenomic results to your patients?	Very confident	28	10.6
	Somewhat confident	76	28.9
	Not very confident	99	37.6
	Not at all confident	60	22.8
Training received	Undergraduate	60	22.7
	Postgraduate	13	4.9
	CME	17	6.4
	None	174	65.9
Would you be interested in receiving additional education or training on pharmacogenomics?	Yes	234	89
	No	16	6.1
	Unsure	13	4.9

Table 3. Factors related to the Attitude toward Pharmacogenomic Test Report (Adjusted analysis -Linear regression)

Variable	Categories	B	95% CI for B		P-value
			Lower	Upper	
	Intercept	3.67	3.34	3.99	<0.001
What is your gender?	Male	0.05	-0.06	0.15	0.382
	Female(ref)	0	.	.	.
Age (in years)	18-24	-0.09	-0.5	0.32	0.66
	25-34	-0.24	-0.58	0.11	0.177
	35-44	-0.2	-0.51	0.11	0.211
	45-54	-0.12	-0.38	0.14	0.375
	55+(ref)	0	.	.	.
How many years have you been practicing?	less than 5 years	0.17	-0.07	0.42	0.164
	5 to 10 years	0.1	-0.12	0.31	0.387
	11 to 15 years	0.13	-0.06	0.32	0.18
	More than 15 years(ref)	0	.	.	.
Nationality	Emiratis	0.01	-0.18	0.2	0.913
	Expatriates	0	.	.	.
Degree	Bachelor	0.2	-0.03	0.43	0.083
	Master	0.19	-0.05	0.44	0.124
	PhD(ref)	0	.	.	.

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Your facility is operated by	Government	0.09	-0.06	0.24	0.254
	Private(ref)	0	.	.	.
Location of your facility	Abu Dhabi	-0.13	-0.24	-0.02	**0.024**
	Al-Ain	0	.	.	.
Your occupation	Physician	0.16	0.01	0.31	**0.038**
	Pharmacist(ref)	0	.	.	.
The setting of your facility	Rural	-0.13	-0.25	-0.01	**0.037**
	Urban(ref)	0		.	.

associated with the attitude score toward pharmacogenomics. Only three factors had a significant association with the Attitude toward the pharmacogenomic test. Physicians had significantly higher attitude scores than pharmacists (p = 0.024). Participants working in Abu Dhabi had significantly higher attitude scores than those working in Al Ain (p=0.038). Similarly, those working in urban areas had significantly higher attitude scores than rural areas (p=0.037).

For the knowledge score, only two factors had a significant association. Physicians had significantly higher knowledge scores than pharmacists (p <0.001), and those working in urban areas had significantly higher knowledge scores than in rural areas (p=0.001) (See Table 4).

When we asked both the physicians and pharmacists about reasons for not following the recommendations of the PGx report, the top cited reason was that they were not sure of the results' accuracy, followed by the fact that they did not understand the report (See Figure 1).

Table 4. Factors related to the knowledge of Pharmacogenomic Test Report (Adjusted analysis -Linear regression)

	Categories	**B**	**95% CI B**		**P-value**
			Lower	**Upper**	
	Intercept	57.11	38.29	75.94	<0.001
Gender	Male	-3.13	-9.19	2.94	0.311
	Female(ref)	0	.	.	.
Age (in years)	18-24	1.9	-22.1	25.9	0.876
	25-34	1.71	-18.23	21.66	0.866
	35-44	1.41	-16.61	19.43	0.878
	45-54	7.46	-7.44	22.36	0.325
	55+(ref)	0	.	.	.
How many years have you been practicing?	less than 5 years	4.86	-9.49	19.21	0.505
	5 to 10 years	3.3	-9.41	16.02	0.609
	11 to 15 years	-3.73	-14.96	7.5	0.514
	More than 15 years(ref)	0	.	.	.
Nationality	Emiratis	-6.65	-17.94	4.65	0.247
	Others	0	.	.	.
Degree	Bachelor	6.66	-6.74	20.06	0.329
	Master	10.62	-3.77	25.01	0.147
	PhD(ref)	0	.	.	.
Your facility is operated by	Government	7.51	-1.23	16.24	0.092
	Private(ref)	0a	.	.	.
Location of your facility	Abu Dhabi	-5.3	-11.78	1.19	0.109
	Al-Ain	0	.	.	.
Your occupation	Physician	22.61	13.75	31.46	**<0.001**
	Pharmacist(ref)	0	.	.	**.**
The setting of your facility	Rural	-11.92	-19.02	-4.83	**0.001**
	Urban(ref)	0	.	.	**.**

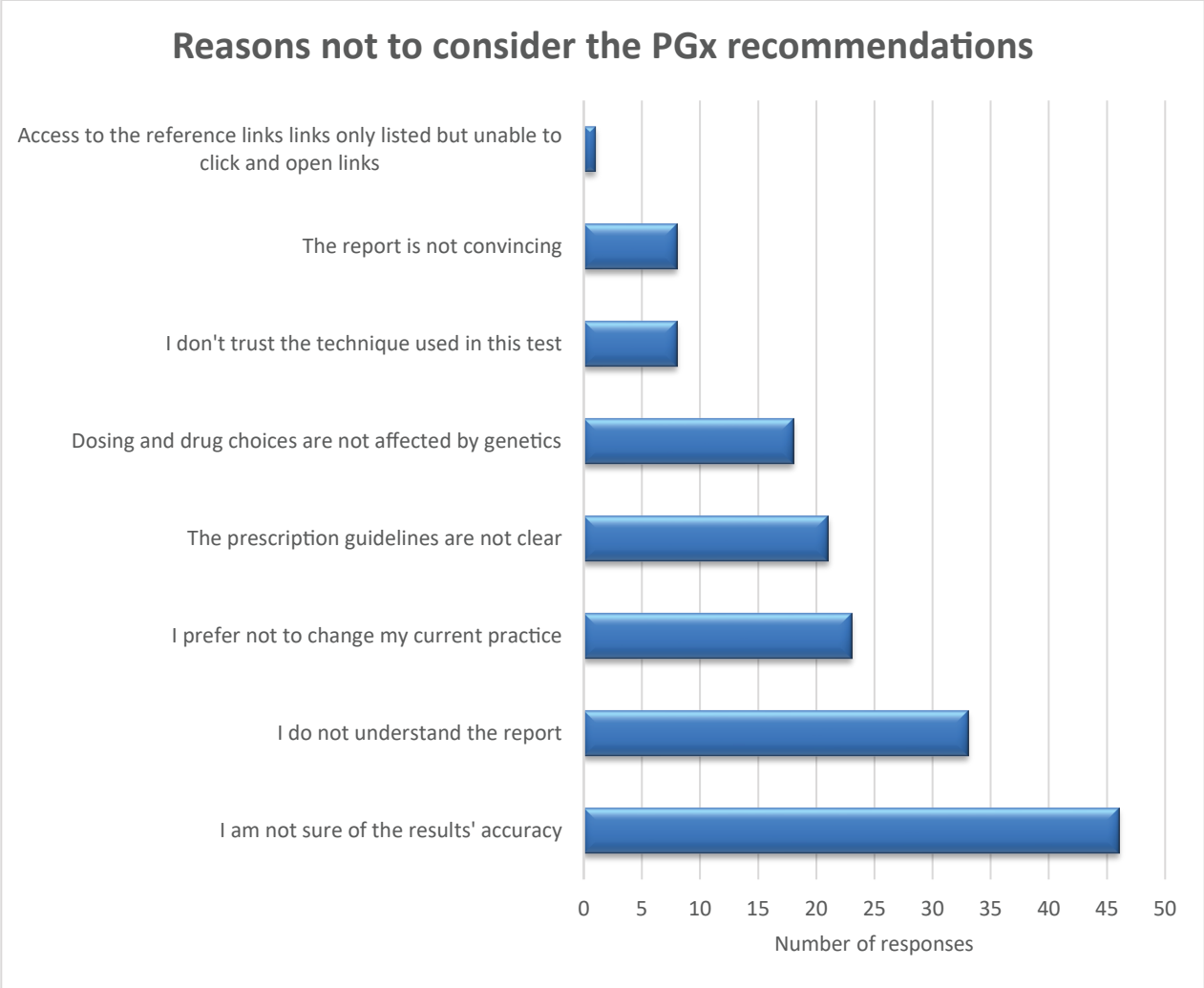

Figure 1. Reasons not to consider the recommendations of the PGx report from EmHeart

DISCUSSION

This cross-sectional study assessed healthcare professionals' knowledge and attitudes toward pharmacogenomic testing in the UAE. A comprehensive survey was conducted among 264 participants, including physicians and pharmacists. The findings highlight significant knowledge and confidence gaps regarding pharmacogenomics while indicating a solid willingness to receive further training. This is the first study that uses a pharmacogenomic sample report to assess knowledge in a group of healthcare practitioners. We further enhanced the analysis by examining the correlation between demographic, practice, and experience variables and attitude and knowledge in pharmacogenomics proxied by numerical scores. Overall, the findings underscore a pressing need for targeted educational programs to enhance the effective integration of pharmacogenomics into clinical practice, particularly for those showing lower awareness and engagement with this evolving field.

Our primary frequency analysis revealed that a majority (64.4%) of the respondents have heard of pharmacogenomics, suggesting a reasonable level of awareness within the UAE healthcare community. These levels are higher than those from India[24] but lower than those reported from the USA[25] or Ghana[26]. Nevertheless, few practitioners (4.9%) have ordered pharmacogenomic tests for their patients, highlighting a significant gap between awareness and practical application in clinical settings. This percentage is profoundly less than reported from earlier surveys in the USA[16] or European countries[27]. However, it is close to that reported in a similar study conducted in Malaysia, where 5.8% of participating doctors and pharmacists have ever ordered or recommended pharmacogenomic testing[28].

Notably, only 27.3% of respondents have seen an actual patient genetic testing report, while a majority (62.1%) have never encountered one. This suggests limited practical exposure to genetic data, which may effectively affect the ability to integrate pharmacogenomics into clinical practice.

Confidence levels vary, with 37.6% not very confident

and 22.8% entirely not confident in their ability to explain pharmacogenomic results. These results are similar to those reported in a comprehensive review of 22 studies assessing pharmacists' confidence in applying pharmacogenetics[29]. Comparable results were extracted in another systematic review of general practitioners' attitudes toward genetic testing in general. Ten studies of the latter review highlighted a lack of general practitioners' confidence in interpreting and discussing genetic results[30]. These observations indicate a need for improved educational support to build confidence in interpreting and communicating pharmacogenomic information.

Regarding the training environment in the UAE, a substantial proportion of the respondents (65.9%) reported receiving no training in pharmacogenomics, underscoring a significant educational gap. A comparable training gap was recognized in a similar survey of hospital pharmacists in neighboring Saudi Arabia[8]. Despite the gaps in training and confidence, a high percentage of respondents (89%) expressed interest in receiving additional education or training on pharmacogenomics, indicating an intense desire among healthcare professionals to enhance their understanding and skills in this area[31].

The data elucidates several critical aspects of the current state of pharmacogenomics in healthcare. While there is a reasonable awareness of pharmacogenomics among healthcare practitioners, there is a notable discrepancy between this awareness and the actual application of pharmacogenomic testing in clinical practice. The limited exposure to actual genetic reports and the low confidence in handling pharmacogenomic data suggest that practitioners may need more tools and knowledge to apply pharmacogenomics effectively. The expressed interest in further education, combined with the current low levels of formal training, highlights a substantial opportunity for developing comprehensive educational programs. Such initiatives could bridge the knowledge gap, enhance practical skills, and ultimately facilitate the integration of pharmacogenomics into routine clinical practice[27,32].

Furthermore, we explored the correlation between different variables and respondents' attitudes and knowledge. The analysis indicates no significant difference in attitudes and knowledge about pharmacogenomics between genders, age groups, nationality, years of experience, and the highest educational degree.

However, there was a noticeable variation in attitudes and knowledge based on specialty. Notably, Physicians had higher attitude (Mean = 3.97) and knowledge scores (Mean = 90.22), significantly different from pharmacists. These findings contrast previous reports from Qatar and Malaysia, in which pharmacists had more positive attitudes toward pharmacogenetics than physicians[28,33]. Also, practitioners in urban locations demonstrated significantly higher knowledge and more positive attitudes than those in rural areas. A similar observation is reported in the USA, where pharmacogenomics became routine in urban areas and lagged in rural areas, mainly due to educational barriers[34]. Noteworthy, the level of knowledge reported here was higher than earlier reports from the UAE[13].

Previous data suggests that demographic factors like the type of practice and the facility's geographical location significantly influence healthcare practitioners' knowledge and attitudes toward pharmacogenomic testing. These factors could be due to differing levels of exposure to pharmacogenomic practices, educational opportunities, or the variability in the integration of pharmacogenomics in different healthcare settings. These insights could be crucial for tailoring educational and training programs to address gaps in knowledge and attitude, especially in demographics that show lower awareness and acceptance of pharmacogenomic testing. Improving such interventions could enhance the implementation and effectiveness of pharmacogenomic-guided treatments across various healthcare settings and demographic groups[35–37]. Indeed, the Implementing Genomics In Practice (IGNITE) Network has performed a comprehensive analysis of the critical constructs for a sustainable implementation of genomic medicine in practice, and the providers' education was at the forefront of these factors[38].

The strength of this study is that it is the first study in the UAE that uses a pharmacogenomic sample report to assess knowledge in a group of healthcare practitioners. Moreover, the survey was reviewed by international and regional experts in the field of pharmacogenomics. Another strength is including both physicians and pharmacists, as both will be the adopters of pharmacogenomics in UAE. Therefore, their insights are of value to the stakeholders. The limitations of this study are the inherent limitations of cross-sectional study design, in which the results are bound by the time and place of the study. Moreover, the results cannot be generalized as it was conducted in only one Emirate, Abu-Dhabi. Therefore, we recommend scaling up this study to include all the seven emirates of the UAE.

CONCLUSION

This study underscores a critical gap between awareness and the practical application of pharmacogenomics among healthcare practitioners in the UAE. While many professionals recognize its importance, limited exposure to genetic reports and low confidence in result interpretation hinder its clinical integration. Our findings highlight the urgent need for structured educational programs to enhance knowledge and confidence, particularly for those with minimal training or exposure.

Direct experience with pharmacogenomic reports, through clinical practice or formal education, is a key driver of improved understanding and positive attitudes. This suggests that integrating hands-on training into medical and pharmacy curricula and continuing professional development programs could be an effective strategy for bridging existing gaps.

Future research should explore scalable educational models tailored to different practitioner demographics, assess the long-term impact of training initiatives on clinical adoption, and investigate systemic barriers to pharmacogenomics implementation across the UAE. Expanding this study

nationwide and incorporating qualitative insights from practitioners could further refine strategies to facilitate the seamless integration of pharmacogenomics into routine healthcare practice.

AUTHOR CONTRIBUTIONS

"Conceptualization.; Z.A.M. & A.T.R. methodology, Z.A.M., E.M. & A.T.R.; Data analysis; EM SurveyMonkey software; ATR validation, ZAM & ATR; data collection, ATR, B.B., M.A., O. A., K. A., S. A., K. A., N. A., H. A., M. A. resources, ATR., granting ethical approvals, B.R.A. Original draft preparation, ZAM & ATR, EM, BB. visualization, EM, ATR funding acquisition and management, ATR. All authors have read and agreed to the published version of the manuscript."

CONFLICT OF INTEREST

The authors report no competing interests to declare.

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