Saudi Pharmaceutical Journal 29 (2021) 53–58

Contents lists available at ScienceDirect

Saudi Pharmaceutical Journal

journal homepage: www.sciencedirect.com

Original article

Knowledge, perception, and confidence of hospital pharmacists toward pharmacogenetics in Jeddah, Kingdom of Saudi Arabia

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ARTICLE INFO

Article history:
Received 22 August 2020
Accepted 8 December 2020
Available online 30 December 2020

Keywords:
Confidence
Knowledge
Pharmacist
Pharmacogenetics
Perception
And Saudi

ABSTRACT

Background: Integrating pharmacogenetics (PGx) testing into clinical practice leads to personalized medicine, which improves treatments' efficacy and safety. Successful implementation of such a service requires sufficient knowledge, perception, and self-confidence among healthcare providers, especially pharmacists.
Objectives: To evaluate governmental hospital pharmacists' knowledge, perception, and self-confidence toward PGx testing in Jeddah, Kingdom of Saudi Arabia.
Method: This cross-sectional study was conducted using previously validated questionnaire. Pharmacists working in five randomly selected general governmental hospitals in Jeddah between August and October 2019 were interviewed. Comparative and descriptive analyses were used to analyze the data, and the significance level was at *P*-value < 0.05.
Results: A total of 119 pharmacists with a mean (±SD) age of 31.2 (±5.05) years were included with a response rate of 79.3%. The average total mean (±SD) score for PGx knowledge-based questions was low (2.4 ± 1.09 out of 5). Most of the participants, with a total mean score of (10.1 ± 1.6 out of 12), revealed a positive perception toward PGx testing and its implications. A moderate self-confidence score for utilizing PGx testing (4.3 ± 2.3 out of 8) was observed among the participants. Pharmacists who had completed postgraduate studies had a statistically higher mean knowledge score ($P = 0.006$) compared with pharmacists with undergraduate degrees.
Conclusion: Governmental hospital pharmacists have limited knowledge and understanding about PGx testing; however, the majority expressed a high level of awareness and agreed that PGx testing is a valuable tool for enhancing drug efficacy and safety. The study also highlighted the importance of improving pharmacists' knowledge about PGx testing, which will help them in implementing such a valuable service into their clinical practice in Saudi hospitals.

1. Introduction

Pharmacogenetics (PGx) studies the influence of genetic variations on a patient's response to a particular drug (Crews et al., 2012; Jain, 2002). Clinical implementation of PGx testing into clinical practice leads to personalized medicine, which promotes safe and effective selection and doses of drugs and decreases the overall cost of healthcare (Haga et al., 2012; Hippman and Nislow, 2019). Over the past several years, the United States' Food and Drug Administration (U.S. FDA) and the European Medicines Agency (EMA) have incorporated PGx information and recommendations into drug labeling (Kim et al., 2017; Klein et al., 2017). In addition, the advancement of genotype programming has made PGx testing a practical tool for providing personalized medicine and improving the quality of health practices. Globally, ongoing initiatives for PGx implementation have been launched in the United States, Europe, and Asia (Krebs and Milani, 2019). Given the importance of PGx implementation, the Center of Innovation in Personalized Medicine was established at King AbdulAziz University (KAU), Saudi Arabia, in 2012. This center plays a pivotal role in the field of PGx research and education in Saudi Arabia (Abu-Elmagd et al., 2015).

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jsps.2020.12.006

While the PGx test for some U.S. FDA-approved drugs are clinically available, many barriers still interfere with implementing PGx testing into clinical settings (Moyer and Caraballo, 2017; Stanek et al., 2012). The main barriers are the lack of knowledge, awareness, and self-confidence about PGx testing among pharmacists and other healthcare professionals (Johnson, 2013; Klein et al., 2017). Other barriers that interfere with the application of PGx testing include the lack of evidence of the clinical benefits of PGx testing, the lack of availability of the PGx tests in some hospitals, and limited resources (Johnson, 2013; Klein et al., 2017). According to the American Society of Health-System Pharmacists, pharmacists should be involved in recommending PGx testing for their patients and in making medication and dosage recommendations based on the PGx testing results. In addition, pharmacists should be involved in educating patients and colleagues about PGx testing and its clinical applications (Elewa and Awaisu, 2019; Owusu-Obeng et al., 2014). Therefore, improving pharmacists' knowledge and experience in PGx testing plays a vital role in the successful implementation and the application of PGx testing in clinical practices.

Numerous studies have been conducted worldwide to evaluate health-care professionals' knowledge and attitudes toward PGx testing and their educational needs to carry PGx from bench to bedside. Such studies were conducted in the United States, Canada, Australia, Europe, and Africa (De Denus et al., 2013; Kudzi et al., 2015; Mccullough et al., 2011; Muzoriana et al., 2017; Tuteja et al., 2013; Yau et al., 2015). However, limited studies have been conducted to assess the healthcare professionals' knowledge and attitude toward PGx testing in the Gulf countries. To date, only two studies have been published in Qatar and Kuwait (Albassam et al., 2018; Elewa et al., 2015). Genetic diseases are substantially higher in Saudi Arabia compared to other Gulf countries (Monies et al., 2017), due to the strong preference for cousin marriages in the general population. Noticeably, a considerable number of the medications commonly prescribed in Saudi Arabia are metabolized by cytochrome P450 (CYP450) enzymes, including warfarin, clopidogrel, statins, and glimepiride (AlKhamees et al., 2018). Saudi Arabia has a high prevalence of genetic polymorphisms in cytochrome P450 (CYP450) enzymes, which greatly influence drugs' efficacy and safety. For example, the genetic polymorphism of the CYP2C enzyme, which is responsible for the metabolism of several drugs, including warfarin, has been reported with high frequency among Saudis (Saour et al., 2011). Specifically, in Riyadh, the CYP2C9*2 or CYP2C9*3 alleles are associated with reduced enzyme activity and were reported with frequencies of 11% and 9%, respectively. Patients on warfarin with CYP2C9*2 and CYP2C9*3 alleles had higher bleeding incidences and required a 40% less warfarin dose to cause effective anti-coagulation (Saour et al., 2011). Regardless of the high prevalence of prevalence of polymorphisms in genes encoding CYP450 enzymes in Saudi Arabia, clinical applications of PGx testing are quite limited for some pharmacogenetically high-risk medications despite their availability. No studies have been conducted to assess the knowledge of health professionals in Saudi Arabia about PGx testing. Given the pharmacists' vital roles in the delivery of PGx testing, this study aimed to evaluate governmental hospital pharmacists' knowledge, perception, and self-confidence toward PGx testing and to identify their preferred learning format for their future education in pharmacists and to identify the barriers to the clinical applications of PGx in Jeddah.

2. Materials and methods

2.1. Study design and data collection procedures

This descriptive, cross-sectional survey was conducted in Jeddah between August and October 2019. Jeddah is a city located in Western Saudi Arabia along the Red Sea coast. The study included pharmacists working in five randomly selected governmental hospitals by using a simple random method. The city was divided into five regions: north, south, east, west, and center. For each region, all governmental hospitals names were written on pieces of paper and placed in a bowl. Then one governmental hospital name was randomly selected. This was repeated for all five regions. The hospitals included were the King Abdullah Medical Complex in the north region, the King AbdulAziz Hospital Al Mahjar in south region, the East Jeddah General Hospital in the east region, the King Fahad General Hospital in the west region, and the King AbdulAziz University (KAU) Hospital in the center region of Jeddah. The pharmacists who were interviewed had all graduated from Saudi Universities with either Doctor of Pharmacy (PharmD) or Bachelor of Pharmacy (BPharm) degrees and completed their education and training in Saudi Arabia. All the pharmacists at each hospital were approached and the aim of the study was introduced to them. Those who agreed to participate were provided with a detailed explanation about the study's aim and were assured that participation was strictly voluntary and confidential. All interviews were performed by four senior PharmD students. The principle investigator trained the students to conduct the research involving human participants.

The sample size calculation was carried out based on the assumption that the response rate is 50%. The sample size was determined using the Raosoft sample-size calculator providing a confidence interval of 95% and a margin of error of 5%. Based on the Ministry of Health's statistical yearbook, the target population was 230 pharmacists currently practicing in the governmental hospitals in Jeddah. The minimum sample size was estimated as 115 pharmacists.

Ethical approval

The study was approved by the Research Ethical Committee of the School of Pharmacy at KAU in (PH-111–40). Informed consent was obtained from all participants prior to their participation.

2.2. Study instrument

To conduct our survey, a previously validated and published questionnaire was utilized (Albassam et al., 2018). The questionnaire was in English and consisted of five sections. The first section included questions regarding the participants' demographic and professional characteristics. Postgraduate studies involved any degree after the bachelor's degree, such as a masters, fellowship, and PhD. The second section consisted of five questions to evaluate each pharmacist's knowledge of PGx testing. A score of 1 was given for each correct answer or zero for each question answered wrong. Thus, a maximum score of 5 can be achieved by correctly answering all the knowledge-based questions. A score of 4.0 or higher was considered good knowledge, a score <4.0 or higher than 2.5 was considered moderate knowledge, and a score of 2.5 or less was considered poor knowledge. The third section included six questions regarding pharmacists' perceptions of PGx testing and its implication. The fourth section included four questions to assess participants' self-confidence in utilizing PGx testing in their clinical practice. A 3-point Likert scale measured responses to both perception and self-confidence-based questions (i.e., agree, neutral, or disagree).

As for the pharmacists' perceptions, a score of 2.0 was given for each time a participant answered "agree," 1.0 for "neutral," and 0.0 for "disagree." Thus, the maximum score a participant can achieve is by answering "agree" to all of the perception questions was 12. The total mean score of all participants was calculated, and a total mean score of 10.0 and higher was considered a positive perception. On the other hand, a total mean score of 6.0 or less was considered a negative perception.

For the self-confidence-based questions, a score of 2.0 was given for each time a participant answered "agree," 1.0 for "neutral," and 0.0 for "disagree." Thus, the maximum score a participant can achieve by answering "agree" to all of the self-confidence-based questions was 8.0. The total mean score of all participants was calculated, and a total mean score of 6.0 or more was considered high. On the other hand, a total mean score of 4.0 or less was considered low.

In the last section, participants' preferred continuing-education learning styles and the challenges and obstacles they face to implement PGx testing in their clinical practice were investigated.

2.3. Data analysis

Data were entered and analyzed using SPSS version 18.0 software (SPSS Inc., USA). Descriptive statistics, including mean (±SD), frequencies, and percentages, were used to summarize the demographic variables and participants' knowledge, perception, and self-confidence toward PGx testing. T-tests were used to assess the association of different demographic factors with participants' knowledge, perception, and self-confidence toward PGx testing. The significant level was at *P*-value < 0.05.

3. Results

A total of 150 pharmacists were approached to participate in the survey: 119 agreed and completed the questionnaires (response rate of 79.3%). The mean (±SD) age of the participants was 31.2 years (±5.05). Most participants (93) (78.1%) were younger than 35, and 99 (83.2%) had<10 years of experience. Only 36 (30.3%) pharmacists completed PGx-testing-related training or education, and 34 (28.6%) applied PGx testing in their practice setting. Only 33 (27.7%) counseled patients on the results of their PGx testing. Participants' demographic characteristics and professional information are presented in Table 1.

Table 1
Demographic characteristics and professional information of the participants (N = 119).

Variable	Number of participants % n (%)
Age	
<35 years	93 (78.1)
>35 years	26 (21.8)
Gender	
Male	50 (42)
Female	69 (58)
Experience	
<10 years	99 (83.2)
>10 years	20 (16.8)
Hospital based	
King Abdullah Medical Complex	14 (11.8)
King AbdulAziz University Hospital	27 (22.7)
East Jeddah Hospital	23 (19.3)
King Fahad General Hospital region	27 (22.7)
King AbdulAziz Hospital Al Mahjar	28 (23.5)
Clinical based	
Outpatient pharmacists	32 (26.9)
Inpatient pharmacists	33 (27.7)
Clinical pharmacists	24 (20.2)
Others	30 (25.2)
Postgraduate	
Yes	35 (29.4)
No	84 (70.6)

3.1. Participants' knowledge about pharmacogenetics testing

The mean (±SD) knowledge score for all participants was 2.4 (±1.09) out of 5.0, which indicates that most participants had low knowledge of PGx testing. A total of 80 participants (87.2%) knew that PGx testing plays an essential role in identifying drug–drug interactions, but only 39 (32.8%) knew that it is not currently available for most medications. Most, 63 (52.9%), knew that the package insert for warfarin includes a warning that patients with specific genetic variants have altered drug metabolisms and that dosage adjustment is required for them. Participants' knowledge about PGx is presented in Table 2.

3.2. Participants' perceptions toward pharmacogenetics and its implications

The mean (±SD) perception score of participants was 10.1 (±1.6) from a total of 12, which indicated that most participants have a positive perception toward PGx testing and its implications and agreed to most of the perception-based questions. Although only 63 (52.9%) agreed that PGx testing is relevant to their current clinical practices, most of them, 69 (80.7%), agreed that PGx testing should be applied to clinical practice. Around 88 (73.9%) agreed that they should provide information on appropriate use of PGx testing. However, only three (2.5%) disagreed that PGx testing will improve their ability to more effectively control drug therapy expenditures.

3.3. Participants' self-confidence in utilizing pharmacogenetics in their practice settings

The mean (±SD) self-confidence score of participants was 4.3 (±2.3) from a total of 8.0, suggesting that participants had moderate self-confidence in utilizing PGx testing in their practice. A total of 51 (42.9%) declared that they could confidently identify drugs that need PGx testing. Only 31 (26.1%) confidently determined available PGx testing within the Saudi health-care systems. Forty-five (37.8%) participants felt confident in applying the results of PGx testing to drug therapy selection and dosing accurately.

3.4. Factors influencing pharmacists' knowledge, perceptions, and self-confidence regarding pharmacogenetics testing

Table 3 represents the factors associated with participants' knowledge, perception, and self-confidence mean scores regarding PGx testing. Pharmacists older than 35 years or with>10 years of experience had better knowledge, more positive perceptions toward PGx testing and its implications, and more self-confidence than younger pharmacists and those with<10 years of experience. However, the differences were not statistically significant. Pharmacists with postgraduate studies had a statistically higher knowledge mean score ($P = 0.006$).

3.5. Participants preferred continuing-education program learning styles and the challenges they face to implement pharmacogenetics testing on their clinical practice

The most preferred continuing-education learning styles were workshops or seminars (72) (60.5%), while self-directed learning (5) (4.2%) was the least preferred. Additionally, 26 (21.8%) of pharmacists preferred learning during an internship year and the remaining 14 (11.8%) favored Internet-based-learning. Lack of proper training or education was the main challenge reported by 52 (43.7%) that they face to implement PGx testing. A total of 28 (23.5%) reported a lack of clinical guidance, 13 (10.9%) reported a lack of testing devices, and 12 (10.15%) reported a shortage of per-

Table 2
Participant's knowledge about PGx testing (N = 119), Saudi Arabia October-December 2019.

Question assessing Knowledge	Correct answer	Answering correct n (%)	Answering wrong n (%)	Answering Don't know n (%)
Genetic determinants of drug response change over a person's lifetime	**False**	84 (70.6)	14 (11.8)	21 (17.6)
The package insert of Warfarin includes a warning about altered metabolism in individuals who have specific generic	**True**	63 (52.9)	5 (4.2)	51 (42.9)
PGx testing is currently available for most medications?	**False**	39 (32.8)	37 (31.1)	51 (42.9)
PGx testing has an essential role in individualizing response to drugs	**True**	100 (84)	4 (3.4)	15 (12.6)
PGx testing has an essential role in identifying drug -drug interaction	**True**	80 (87.2)	8 (6.7)	31 (26.1)

Table 3
Factors influencing pharmacist's knowledge, perceptions and self-confidence about PGx, (N = 119), October-December-Saudi Arabia.

Characteristics	Factors influencing pharmacist's knowledge, perceptions and self-confidence about PGx testing					*P-value*
	Knowledge mean score n (%)	*P-value*	Perceptions mean score n (%)	*P-value*	Self-confidence mean score n (%)	
Gender						
Male	2.4 (0.95)	0.14	10.2 (1.59)	0.94	4.4 (2.15)	0.16
Female	2.4 (1.1)		10.1 (1.67)		4.3 (2.49)	
Age						
< 35 years	2.4 (1.01)	0.82	10.1 (1.60)	0.83	4.3 (2.29)	0.26
> 35 years	2.5 (1.16)		10.2 (1.8)		4.5 (2.6)	
Postgraduate studies						
Yes	2.77 (0.84)	**0.006***	10.7 (1.6)	0.81	3.85 (2.2)	0.54
No	2.36 (1.09)		9.94 (1.60)		4.5 (2.3)	
Experience						
< 10 years	2.4 (0.97)	0.36	9.7 (1.74)	0.87	4.3 (2.35)	0.098
> 10 years	2.7 (1.33)		10 (1.61)		4.4 (2.37)	

* P value significant < 0.05, using *t*-test.

sonal. While the cost of the testing device was the least challenge reported 6 (5%).

4. Discussion

In Saudi Arabia, the practice of PGx testing is limited to some specialist cancer centers. Given the critical roles pharmacists play in the clinical application of PGx testing, this study aimed to determine their knowledge, perceptions, and self-confidence about PGx testing among practicing governmental hospital pharmacists in Jeddah. The present results clearly show that governmental hospital pharmacists have limited knowledge and understanding of PGx testing. However, they expressed significantly positive attitudes toward implementing PGx testing into their clinical practices.

The direct assessment of pharmacists' knowledge was evaluated via five different questions. It was clearly noted that hospital pharmacists have limited knowledge and understanding of PGx testing (average knowledge score, 2.4 ± 1.09 out of 5). About 42.9% of the respondents did not know that warfarin's package insert includes a specific genotype warning. Also, 31.1% and 42.9% of respondents selected the wrong answer or reported being unaware, respectively, when asked about the availability of PGx testing for some medications. A similar survey was conducted in Kuwait by Albassam et al. (2018) to assess hospital pharmacists' knowledge regarding PGx testing. Surprisingly, pharmacists working in Saudi governmental hospitals had greater knowledge regarding PGx testing compared to hospital pharmacists working in Kuwait. For instance, only 16.2% of the hospital pharmacists in Kuwait, compared with 73.4% of hospital pharmacists in Saudi Arabia, recognized that genetic determinants of drug responses do not change over a person's lifetime. Several factors might contribute to the higher PGx knowledge observed among Saudi hospital pharmacists. In 2001, KAU introduced the first Pharm. D program in Saudi Arabia. Currently, 15 colleges of pharmacy offer the Pharm. D degree in Saudi Arabia (Alsultan et al., 2013). Kuwait University is the only one that offers a Bpharm degree in Kuwait, and a two-year add-on Pharm. D was started in 2016 (Albassam et al., 2018). In addition, around 29% of the pharmacists interviewed in our study held a postgraduate degree compared to 13.1% of the pharmacists in the study conducted in Kuwait. In the United States, Canada, UK, and, France continuing education has become mandatory for renewing a pharmacist's license (Driesen et al., 2007). Among the Gulf countries, Saudi Arabia has mandatory continuing education systems for pharmacists to maintain their licenses. In Saudi Arabia, to maintain a license, a pharmacist needs to complete 20 h of continuing education annually (Hasan, 2009). However, in Kuwait, continuing education for pharmacists is not mandatory (Aldosari et al., 2020). Continuing education programs will likely increase pharmacists' knowledge about PGx, which is essential for the appropriate delivery of PGx testing.

In general, there were no significant differences in knowledge and perceptions toward PGx testing among the interviewed pharmacists. However, we have observed that pharmacists having completed postgraduate studies had a statistically higher PGx knowledge score than pharmacists with undergraduate (PharmD or BPharm) degrees. We did not evaluate the difference in the mean score knowledge between pharmacists with PharmD or BPharm degrees. In contrast, Tuteja et al. (2013) reported that pharmacists with a PharmD education scored significantly higher in the knowledge of PGx testing than those with a BPharm degree. This could indicate that PharmD-trained pharmacists were exposed to clinical practices more than BPharm graduates; thus, they had more experience in the PGx area (Tuteja et al., 2013).

The lack of knowledge regarding PGx testing reported in our study could be attributed significantly to the fact that PGx as a course is not included in the curricula of undergraduate pharmacy programs in Saudi Arabia. Undergraduate pharmacy students enrolled in PharmD or BPharm programs in Saudi universities are exposed only to the basic concepts about PGx through the pharmacology courses. Therefore, the students may lack the required

knowledge and training to implement PGx testing into clinical practice. Specifically, the basic concepts of PGx were recently introduced to the KAU PharmD program in 2016 through a total of four hours of lectures in the pharmacology course. In fact, the number of PGx lectures is lower than that recommended by the International Society of Pharmacogenomics (Gurwitz et al., 2005). A more valuable step would be to integrate PGx into the KAU University PharmD program curricula as a full course for a complete academic semester. This initiative would help provide PharmD graduates with the required knowledge about PGx testing before practicing it clinically during their last year in the PharmD program. Indeed, improving PGx courses at Saudi universities will prepare pharmacists to implement PGx testing in pharmacotherapy. Educators have acknowledged the need for enhanced PGx education since the early 2000 s. In the United States, the PGx course has been integrated into the curricula of most colleges of pharmacy since 2007 as a required competency for pharmacy education accreditation (Murphy et al., 2010; Vlasses et al., 2016). Therefore, higher knowledge was reported among pharmacists practicing in the United States compared to those in Saudi Arabia (Yau et al., 2015).

Another reason for the lack of knowledge among interviewed pharmacists might be the nonfunctional clinicians' role in requesting PGx tests and interpreting the results. The lack of knowledge among physicians is a common problem in various countries, which hinders the successful implementation of PGx testing. For example, Stanek et al. (2012) surveyed 397,832 physicians across the United States and only 10.3% felt adequately familiar with PGx testing (Stanek et al., 2012; Haga et al., 2012; Johansen Taber and Dickinson, 2014; Kudzi et al., 2015). To date, no published studies have evaluated the physician's knowledge regarding PGx testing in Saudi Arabia.

The lack of self-confidence among pharmacists is considered another major challenge in implementing PGx testing. About 36% of respondents could not identify drugs that require PGx testing or utilize PGx laboratory results. Consistent with previous studies, the observed lack of self-confidence among pharmacists could be attributed to their lack of adequate education and training (Tuteja et al., 2013; DA et al., 2017; Albassam et al., 2018). The interviewed pharmacists contributed their opinions regarding the preferable source of information to improve their knowledge and self-confidence. Among the participants, 78% of participants preferred attending workshops/seminars. About 43% thought it was essential to involve the topic in clinical practice during the internship year, and 31.6% of pharmacists voted for online-based learning. Thus, our findings strongly emphasize the importance of continuing pharmacy education and training to assist in implementing PGx into clinical practice.

Despite the significant low score of knowledge among interviewed pharmacists, 80% of them expressed significantly positive attitudes toward the relevance of PGx testing and its benefits in clinical practice. Further, pharmacists agreed on their role in providing health-care professionals with information regarding PGx testing. They also believed in the importance of PGx to control drug therapy expenses and improve drug efficacy and safety. In agreement with our results, several studies reported pharmacists' willingness to implement PGx testing to assist physicians in making appropriate treatment decisions (De Denus et al., 2013; Elewa et al., 2015; Unertl et al., 2015; Yau et al., 2015; Albassam et al., 2018). This positive perspective can be attributed to the anticipated benefits of PGx on drug safety and efficacy.

The study has three main limitations. First, the survey was conducted in one region of Saudi Arabia, thus generalizing the results to other regions may not be possible. Second, the use of Likert-scale questions may have bias tendencies in selecting neutral answers to avoid being unfamiliar with the topic. Third, the mean score for knowledge between pharmacists with different degrees was not evaluated, which might significantly affect the knowledge of PGx among them since pharmacists earning higher degrees and/or learning more clinical practices gained experiences in different pharmacy-related topics, including PGx.

5. Conclusion

The present study revealed that governmental hospital pharmacists in Jeddah had, in general, limited knowledge and understanding about PGx testing; however, the majority expressed a high level of awareness and agreed that PGx testing is a valuable tool for enhancing drug efficacy and safety. The study also highlighted the importance of providing proper educational resources on PGx for pharmacists at the undergraduate level and ongoing training to successfully deliver PGx services and consultations. The incorporation of PGx into clinical pharmacy practices in Saudi Arabia will undoubtedly improve treatment outcomes, reduce the risk of adverse events, and positively influence the future of patient care. Further, new studies including all pharmacists with different educational and experience backgrounds across Saudi Arabia are recommended.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors thank all the pharmacists who participated in this study.

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