The Practice of Pharmacogenomics Services by Nurses in Saudi Arabia

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ABSTRACT

Objectives: To explore the essential practice of Pharmacogenomics by nurses in Saudi Arabia. **Materials and Methods:** It analyzes a cross-sectional survey discussing the essential practice of Pharmacogenomics by Saudi Arabian nurses. The survey consisted of respondents' demographic information about the crucial practice of Pharmacogenomics services by the nurses at the institution and the responsibility of Pharmacogenomics service. The availability of pharmacogenomics services at the institution, the nurses' requests for any tests, and the number of daily pharmacogenomics tests observed/suspected. Besides, most medications requested Pharmacogenomics tests. The survey was validated through the revision of expert reviewers and pilot testing. Besides, various tests of the reliability of McDonald's ω, Cronbach alpha, Gutmann's λ2, and Gutmann's λ6 were done with the study. The data analysis was done using the Survey Monkey system. Besides, the Statistical Package of Social Sciences (S.P.S.S.), Jeffery's Amazing Statistics Program (J.A.S.P.), and Microsoft Excel sheet version 16. **Results:** A total number of 396 nurses responded to the questionnaire. Of those, almost one-third responded from the central region (138 (34.85%)), and one-fifth responded from the northern region (79 (19.95%)) and Southern area (79 (19.95%)), with statistically significant differences between the provinces (p=0.000). Most of the respondents were from private hospitals (227 (57.32%)) and university hospitals (59 (14.90%)), with a statistically significant difference between working sites (p=0.000). Males responded more than females (251 (63.54%)) versus 144 (36.46%)), with statistically significant differences between all levels (p=0.000). One-quarter of responders107 (27.02%) worked at an organization with pharmacogenomics test services or associated with a Pharmacogenomics tests site 105 (26.52%). Only 103 (26.01%) had cared for any Pharmacogenomics test, and 92 (23.29%) had a Pharmacogenomics request or reporting form at your institution or pharmacy, with statistically significant differences between all answers (p=0.000). The total number of pharmacogenomics test requests was (751) daily, with an average number (of 2.2) per hospital. Most medications had been requested for pharmacogenomics test were Anti-HIV medication 323 (81.98%), Antineoplastic medications 252 (63.96%), Anti-seizure 125 (31.73%), and Anti-Depressant 112 (28.43%). The average score of practice items for Pharmacogenomics at the institution was (1.84). The "Mission of Pharmacogenomics system" obtained the highest score (1.87). The element "The strategic plan of Pharmacogenomics services: was (1.83). In contrast, the lowest score was obtained for "Pharmacogenomics services in the pharmacy" (1.82). The score for the element "The annual plan of Pharmacogenomics services" was (1.83), with a statistically significant difference between the responses (p<0.000). **Conclusion:** The nursing practice of pharmacogenomics services could have been better despite the availability of one-quarter of healthcare organizations. The medications used for pharmacogenomics services were anti-HIV and Anti-Antineoplastic medications. The pharmacogenomics practice was the pharmaceutical department. The nursing practice standardization of pharmacogenomics is warranted with the cooperation of pharmaceutical care services.

Keywords: Nurses, Practice, Pharmacogenomics, Gene Therapy, Saudi Arabia.

INTRODUCTION

Pharmacogenomics is one of the new pharmaceutical care practices in Saudi Arabia.[1] The pharmacogenomics services practice standards for pharmacists were founded by the American Society of Health-System Pharmacists.[2] Other physicians and nurses had other pharmacogenomics practice standards. The practice standards comprised the service's mission, vision, and objectives. The job description of each pharmacogenomics service team, the list of medications involved in the pharmacogenomics test, medication safety, quality management of pharmacogenomics services, and responsibility of the Pharmacoeconomics program. Besides pharmacogenomics guidelines, key performance indicators such as several tests are appropriate or inappropriate.[1,3] The number of patients receiving pharmacogenomics tests and the type of medication required for the test or the disease. Various studies have been conducted on physicians' and pharmacists' practice of Pharmacoeconomics services.[1,4-23] However, nursing practitioners of pharmacogenomics are seldom found in Saudi Arabia locally or in Gulf and Arabic countries. The current study aims to illustrate the musing practice of pharmacogenomics services in Saudi Arabia.

MATERIALS AND METHODS

It analyzes a cross-sectional survey that discussed the nurses' basic knowledge of some items for

pharmacogenomics in Saudi Arabia. It self-reported an electronic survey of the nurses, including nurses from internship to consultant, nurses' specialties, and Saudi Arabia. Non-nurses or students, as well as non-completed, non-qualified surveys, will be excluded from the study. The survey consisted of respondents' demographic information about the essential practice of Pharmacogenomics services by the nurses at the institution and the responsibility of Pharmacogenomics service. The availability of pharmacogenomics services at the institution, the nurses' requests for any tests, and the number of daily pharmacogenomics tests observed/suspected. Besides, methods were used to report the pharmacogenomics tests, and most medications were requested for pharmacogenomics tests.[4-23] The 5-point Likert response scale system was used with closed-ended questions. According to the previous literature with unlimited population size, the sample was calculated as a cross-sectional study, with a confidence level of 95% with a z score of 1.96 and a margin of error of 5%, a population percentage of 50%, and a drop-out rate of 10%. As a result, the sample size will equal 380-420 with a power of study of 80%.[24-26] The response rate required for the calculated sample size is 60-70% and above.[27] The survey was distributed through social media, including applications and telegram groups of nurses. The reminder message had been sent every 1-2 weeks. The survey was validated through the revision of expert reviewers and pilot testing. Besides, various tests of the reliability of McDonald's ω, Cronbach alpha, Gutmann's λ2, and Gutmann's λ6 been done with the study. The data analysis of the nurses' knowledge of some items for pharmacogenomics services at the institution is done through the Survey Monkey system. Besides, the Statistical Package of Social Sciences (S.P.S.S.), Jeffery's Amazing Statistics Program (J.A.S.P.), and Microsoft Excel sheet version 16. It included a description and frequency analysis, good of fitness analysis, and correlation analysis. Besides, inferential analysis of factors affecting the nurse's essential knowledge of some items for Pharmacogenomics services at institutions with linear regression. The STROBE (Strengthening the Reporting of Observational studies in Epidemiology statement: guidelines for reporting observational studies) guided the reporting of the current study.[28]

RESULTS

A total number of 396 nurses responded to the questionnaire. Of those, almost one-third responded from the central region (138 (34.85%)), and one-fifth responded from the northern region (79 (19.95%)) and Southern area (79 (19.95%)), with statistically significant differences between the provinces (p=0.000). Most of the respondents were from private hospitals (227 (57.32%)) and university hospitals (59 (14.90%)), with a statistically significant difference between working sites (p=0.000). Males responded more than females (251 (63.54%)) versus 144 (36.46%)), with statistically significant differences between all levels (p=0.000). Most of the responders were in the age group of 24-35 years (319 (80.76%)), with statistically significant differences between all age groups (p=0.000). Most of the nurses had bachelor nursing (306 (77.66%)) with statistically significant differences between all levels (p=0.000). Most of the responders worked as nursing staff (277 (70.66%)), with a statistically significant difference between positions (p=0.000). Most nurses had a work experience of 4-6 years (209 (52.91%)) and 6-9 years (101 (25.57%)), with a statistically significant difference between years of experience (p=0.000). Most of nurses's specialties was pediatrics (57 ((14.50%)), surgery (54 ((13.74%)), and emergency (53 ((13.49%)) with statistically significant differences between all specialties (p=0.000). One-quarter of responders107 (27.02%) worked at an organization with pharmacogenomics test services or associated with a Pharmacogenomics tests site 105 (26.52%). Only 103 (26.01%) had cared for any Pharmacogenomics test, and 92 (23.29%) had a Pharmacogenomics request or reporting form at your institution or pharmacy, with statistically significant differences between all answers (p=0.000). There was a medium positive correlation between age (years) and nurse's qualifications based on Kendall's tau_b (0.572) and Spearman's rho (0.588) correlation coefficients, with a statistically significant difference between the two factors (p<0.01). There was a medium positive correlation between age (years) and years of experiences based on Kendall's tau_b (0.422) and Spearman's rho (0.449) correlation coefficients, with a statistically significant difference between the two factors (p<0.01). There was a medium negative correlation between age (years) and position held based on Kendall's tau_b (0.537) and Spearman's rho (0.562) correlation coefficients, with a statistically significant difference between the two factors (p<0.01). There was a medium negative correlation between the nurse's qualifications and positions held based on Kendall's tau_b (0.593) and Spearman's rho (0.619) correlation coefficients, with a statistically significant difference between the two factors (p<0.01). (Tables 1 and 2).

Table 1: Demographic, social information.

Nationality	Response Count	Response Percent	*p*-value (X2)
Central area	138	34.85%	0.000
North area	79	19.95%	
South area	79	19.95%	
East area	68	17.17%	
West area	32	8.08%	
Answered question	396		
Skipped question	0		
Site of work	**Response Count**	**Response Percent**	***p*-value (X2)**
M.O.H. Hospitals	18	4.55%	0.000
Military Hospitals	41	10.35%	
National Gaurd Hospital	5	1.26%	
Security Forces Hospitals	30	7.58%	
University Hospital	59	14.90%	
M.O.H. Primary Care Centers	6	1.52%	
Private Hospitals	227	57.32%	
Private Ambulatory Care Clinics	6	1.52%	
Private Primary Healthcare Center	4	1.01%	
Answered question	396		
Skipped question	0		
Gender	**Response Count**	**Response Percent**	
Male	251	63.54%	0.000
Female	144	36.46%	
Answered question	395		
Skipped question	1		
Age	**Response Count**	**Response Percent**	
24-35	319	80.76%	0.000
36-45	60	15.19%	
46-55	11	2.78%	
> 55	5	1.27%	
Answered question	395		
Skipped question	1		

Table 2: Demographic, social information.

Nurses Qualifications	Response Count	Response Percent	*p*-value (X2)
Diploma	17	4.31%	0.000
Bachelor nursing	306	77.66%	
Master	52	13.20%	
Ph D	19	4.82%	
Answered question	394		
Skipped question	2		
Position Held	**Response Count**	**Response Percent**	
Director of the Nursing Department	25	6.38%	0.000
Assistant director of nursing department	27	6.89%	
Supervisor	63	16.07%	
Nursing staff	277	70.66%	
Answered question	392		
Skipped question	4		
Years of experience in a nursing career	**Response Count**	**Response Percent**	
< 1	6	1.52%	0.000
1-3	59	14.94%	
4-6	209	52.91%	
6-9	101	25.57%	
> 9	20	5.06%	
Answered question	395		
Skipped question	1		
The practice area	**Response Count**	**Response Percent**	
Critical Care	32	8.14%	0.000
Emergency	53	13.49%	
Medical	42	10.69%	
Surgical	54	13.74%	
Pediatrics	57	14.50%	
Anesthesia	47	11.96%	
Psychiatry	39	9.92%	
Obstetric and Gynecology	27	6.87%	
Family medicine	25	6.36%	
Ambulatory care	16	4.07%	
General	1	0.25%	
Answered question	393		
Skipped question	3		

The total number of pharmacogenomics test requests was (751) daily, with an average number (of 2.2) per hospital. The highest daily number of pharmacogenomics test requests in the range (1-5) and (6-10) were 52 ((13.16%) and 29 (7.34%), respectively. Most responders filled out pharmacogenomics test forms 347 (88.30%) and sent drug test forms to the pharmacy 131 (33.33%). Those forms mostly had been set to MOH 340 (86.29%), followed by SFDA 308 (78.17%), and drug companies 232 (58.88%). Most medications had been requested for pharmacogenomics test were Anti-HIV medication 323 (81.98%), Antineoplastic medications 252 (63.96%), Anti-seizure 125 (31.73%), and Anti-Depressant 112 (28.43%) (Table 3). The average score of practice items for Pharmacogenomics at the institution was (1.84). The "Mission of Pharmacogenomics system" obtained the highest score (1.87). The element "The strategic plan of Pharmacogenomics services: was (1.83). In contrast, the lowest score was obtained for "Pharmacogenomics services in the pharmacy" (1.82). The score for the element "The annual plan of Pharmacogenomic services" was (1.83), with a statistically significant difference between the responses (p<0.000). All aspects of the practice of nurses ' practice items for Pharmacogenomics at the institution were statistically substantial between responses (p<0.000) (Table 4). The responding nurses mostly agreed that the pharmacogenomics services are the responsibility of the Doctor, with an average score (of 4.45), followed by a pharmacist (3.49) and nurses (3.34), with an average score of practice items for Pharmacogenomics at the institution was (1.83). with a statistically significant difference between the responses (p<0.000) (Table 5). The score for single-test reliability analysis of McDonald's ω was 0.967, Cronbach's α was 0.949, Gutmann's was λ2, 0.967, Gutmann's λ6 was 0.963, and Greater Lower Bound was 0.984 with statistically significant (p<0.05).

Table 3: Pharmacogenomics requesting information.

Have you ever taken any Pharmacogenomics test?	Response Count	Response Percent	*p*-value (X2)
Yes	103	26.01%	0.000
No	216	54.55%	
I do not know	77	19.44%	
Answered question	396		
Skipped question	0		
Are Pharmacogenomics tests available at your institution?	**Response Count**	**Response Percent**	
Yes	107	27.02%	0.000
No	198	50.00%	
I do not know	91	22.98%	
Answered question	396		
Skipped question	0		
Does your institution have an association with a Pharmacogenomics test site?	**Response Count**	**Response Percent**	
Yes	105	26.52%	0.000
No	200	50.51%	
I do not know	91	22.98%	
Answered question	396		
Skipped question	0		
Do you have a Pharmacogenomics request or reporting form at your institution or pharmacy?	**Response Count**	**Response Percent**	
Yes	92	23.29%	0.000
No	219	55.44%	
I do not know	84	21.27%	
Answered question	395		
Skipped question	1		

Table 3: Pharmacogenomics reporting information.

What is the number of Pharmacogenomics tests observed/ requested daily?	Response Count	Response Percent	
1-5	52	13.16%	0.000
6-10	29	7.34%	
11-15	9	2.28%	
16-20	7	1.77%	
21-25	4	1.01%	
26-30	1	0.25%	
I do not know, and I can not specify	5	1.27%	
Nothing	288		
Answered question	395		
Skipped question	1		
How do you report the drug levels?	**Response Count**	**Response Percent**	
I phone the laboratory	39	9.92%	
I verbally inform the patients on routine visits	55	13.99%	
I send the drug test form to the pharmacy	131	33.33%	
I fill the drug-level form	347	88.30%	
Answered question	393		
Skipped question	3		
To whom do you report the Pharmacogenomics results?	**Response Count**	**Response Percent**	
The Ministry of Health (M.O.H.).	340	86.29%	
The Saudi food and drug Authority	308	78.17%	
Drug company	232	58.88%	
Prescriber	154	39.09%	
Pharmacist	113	28.68%	
Pharmaceutical company	51	12.94%	
Answered question	394		
Skipped question	2		
Most of the pharmacogenomics tests requested or observed with the following medications: Pharmacogenomics results?	**Response Count**	**Response Percent**	
Antiplatelet	34	8.63%	
Anti-seizure	125	31.73%	
Anticoagulant	51	12.94%	
NSAIDs or Painkillers	30	7.61%	
Anti-emetics	52	13.20%	
Antineoplastic medications	252	63.96%	
Anti-HIV medication	323	81.98%	
Anesthesia medications	71	18.02%	
Anti-thrombosis	75	19.04%	
Anti-Depressant	112	28.43%	
General Anti-viral	78	19.80%	
Anti-Psychotics	88	22.34%	
Answered question	394		
Skipped question	2		

Factors affecting the essential practice of Pharmacogenomics by the uses at the institution

Factors affecting the perception were analyzed. We adjusted the significant values using the independent samples Kruskal-Wallis test and the Bonferroni correction for multiple tests. ***Nurses' practice of Pharmacogenomics services***

Includes location, site of work, age, gender, and qualification. Nurses practice area, years of experience, position held, you cared any pharmacogenomics test, pharmacogenomics tests available at your institution, The institution has an association with a pharmacogenomics tests site, presence of pharmacogenomics request or reporting form at your institution or pharmacy, The number of pharmacogenomics test. Tow (Site of work and the number of pharmacogenomics tests) out of thirteen were significant differences were statically substantial had released ($p<0.05$). The highest scores (4.7406) were obtained from private hospitals, with statistically significant differences among all sites ($p=0.000$). The zero number of pharmacogenomics test sites with the highest score (4.5908) affected ***nurses's practice of Pharmacogenomics services*** with a statistically significant difference between all answers ($p=0.000$) (Table 6).

The relationship between the nurses' practice of Pharmacogenomics services and factors such as location, work site, Age, gender, and qualifications. Nurses practice area, years of experience, position held, you cared any pharmacogenomics test, pharmacogenomics tests available at your institution, The institution has an association with a pharmacogenomics tests site, Presence of pharmacogenomics request or reporting form at your institution or pharmacy, and the number of pharmacogenomics test. The multiple regression analysis considered perception as the dependent variable and factors affecting it as an expletory variable. There was a strong relationship (R=0. 814 with $p=0.000$) between the nurses' practice of Pharmacogenomics services and its factors. Tow (Site of work and the number of pharmacogenomics tests) out of thirteen were significant differences ($p<0.05$). The multiple regression analysis confirmed that two factors (Site of work and the number of pharmacogenomics tests) explained 41.1% and 48%, respectively, of the positive relationship to the variation in knowledge, with a statistically significant difference ($p=0.000$) and ($p=0.000$). The bootstrap model was also confirmed. Furthermore, the relationship was verified by the non-existence of multicollinearity with the location factor with a Variance Inflation Factor (V.I.F.) of 0.017 and 0.017, respectively less than three or five as a sufficient number of V.I.F. (Table 6).

Factors affecting the perception of responsibility for Pharmacogenomics services

Factors affecting the perception were analyzed. We adjusted the significant values using the independent samples Kruskal-Wallis test and the Bonferroni correction for multiple tests. *Nurses' perception of responsibility for Pharmacogenomics services includes location, work site, age*, gender, and qualification. Nurses practice area, years of experience, position held, you cared any pharmacogenomics test, pharmacogenomics tests available at your institution, The institution has an association with a pharmacogenomics tests site, presence of pharmacogenomics request or reporting form at your institution or pharmacy, The number of pharmacogenomics test. All thirteen factors had no statistically significant differences ($p>0.05$) (Table 7).

The relationship between the nurses' perception of responsibility for Pharmacogenomics services and factors such as location, work site, Age, gender, and qualifications. Nurses practice area, years of experience, position held, you cared any pharmacogenomics test, pharmacogenomics tests available at your institution, The institution has an association with a pharmacogenomics tests site, Presence of pharmacogenomics request or reporting form at your institution or pharmacy, and the

Table 4: Do you have the following items for Pharmacogenomics?

	76-100% implemented		51-75%		25-50%		< 25%		We do not have it		Total	Weighted Average	*p*-value (X2)
The vision of Pharmacogenomics services	1.77%	7	6.31%	25	22.22%	88	16.92%	67	52.78%	209	396	1.87	0.000
Mission of Pharmacogenomics services	1.01%	4	5.05%	20	22.98%	91	18.94%	75	52.02%	206	396	1.84	0.000
The strategic plan of Pharmacogenomics services	1.26%	5	5.56%	22	21.97%	87	19.19%	76	52.02%	206	396	1.85	0.000
The annual plan of Pharmacogenomics services	1.01%	4	4.81%	19	22.03%	87	20.76%	82	51.39%	203	395	1.83	0.000
Policy and procedure of Pharmacogenomics services	1.52%	6	3.80%	15	22.78%	90	19.75%	78	52.15%	206	395	1.83	0.000
Pharmacogenomics services staff competency	1.52%	6	4.04%	16	21.97%	87	20.45%	81	52.02%	206	396	1.83	0.000
Pharmacogenomics services and quality management	1.27%	5	5.60%	22	22.14%	87	18.58%	73	52.42%	206	393	1.85	0.000
Pharmacogenomics services in the pharmacy	2.27%	9	3.28%	13	20.71%	82	21.72%	86	52.02%	206	396	1.82	0.000
Pharmacogenomics services and adverse drug reactions system	2.02%	8	4.80%	19	18.43%	73	23.74%	94	51.01%	202	396	1.83	0.000
Pharmacogenomics Services and Patient Satisfaction	1.26%	5	5.05%	20	20.96%	83	20.96%	83	51.77%	205	396	1.83	0.000
Pharmacogenomics services and medications errors system	1.26%	5	5.81%	23	20.45%	81	21.72%	86	50.76%	201	396	1.85	0.000
Pharmacogenomics services and education and training	1.77%	7	5.32%	21	20.25%	80	21.52%	85	51.14%	202	395	1.85	0.000
Answered											408		
Skipped											0		

Table 5: The Pharmacogenomics services are the responsibility of the following.

	Strongly agree		Agree		Uncertain		Disagree		Strongly disagree		Total	Weighted Average	*p*-value (X2)
Doctors	50.76%	201	45.45%	180	2.27%	9	1.01%	4	0.51%	2	396	4.45	0.000
Pharmacist	6.31%	25	50.00%	198	31.06%	123	12.12%	48	0.51%	2	396	3.49	0.000
Pharmacy technicians	2.53%	10	7.34%	29	55.95%	221	30.63%	121	3.54%	14	395	2.75	0.000
Nurses	1.52%	6	47.34%	187	35.95%	142	13.67%	54	1.52%	6	395	3.34	0.000
Pharmaceutical company	3.56%	14	15.27%	60	58.78%	231	21.37%	84	1.02%	4	393	2.99	0.000
Patients	2.84%	11	30.93%	120	42.53%	165	22.42%	87	1.29%	5	388	3.12	0.000
Answered											408		
Skipped											1		

number of pharmacogenomics test. The multiple regression analysis considered perception as the dependent variable and factors affecting it as an expletory variable. There was a weak relationship (R=0. 302 with p=0.000) between the nurses' practice of Pharmacogenomics services and its factors. All thirteen factors had no statistically significant differences (p>0.05). The bootstrap model was also confirmed (Table 7).

DISCUSSION

Pharmacogenomics, a field combining pharmacology and genomics, is one of the most recent and potential services for healthcare professionals and facilities.[1,3] It involves studying how an individual's genetic makeup influences their drug response. This can help in the early diagnosis of certain diseases, prevent them, and help choose the most cost-effective drug therapy.[1,3] Besides, various medication manufacturers are built based on genetic engineering. Therefore, implementing pharmacogenomics, which refers to using genetic information to guide drug therapy, requires several things, including knowledge and best practices.[3] The pharmacogenomics services team consists of physicians, nurses, and pharmacists. The current research emphasizes the nursing practice of pharmacogenomics services to improve the level of services and implement the pharmacogenomics national and international standards. It was a cross-sectional study with convenience sampling methods due to the difficulty in random sampling and the uncertainty documented in nursing distribution. The sample size is suitable based on requirements calculation with a high-reliability validation test that is better than the previous study[20,22,23] and lower than others.[21] The nursing geographic distribution was significantly different, with a higher percentage in the central region, the number of hospitals being higher than in other locations, and pharmacogenomics services probably being viable. However, it might be good for various geographical regions to reflect the actual situation of pharmacogenomics nursing knowledge among various Saudi areas. The majority of nurses from private hospitals have unclear reasons. The male nursing gender was higher than the female in the previous study,[22] which was not expected because female nursing is higher than male nursing in private hospitals. Most nurses were young with bachelor's degrees and working staff, which was expected because new graduate nurses were more willing to participate in the survey than old graduates. However, although they were young nurses, most of them had more than four years of experience, similar to a previous study,[21,22,29] which means they could practice pharmacogenetics services with a low number of years of experience. The nurses were working with various medical departments with statistical significance, but it was not clinically significant, and it was good to show the nurse's specialty and knowledge of pharmacogenomics. One-third of nurses cared for pharmacogenomics

Table 6: Multiple regression of Factors with the nurses' practice of Pharmacogenomics Services.

Model						Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		R	R Square	F	Sig.	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	V.I.F.
1	(Constant)	.814[b]	.663	55.702	.000[b]	1.572	.323		4.866	.000	.936	2.207	1.572	.323
	Location					.023	.024	.032	.954	.341	-.024	.069	.023	.024
	Site of work					.198	.017	.411	11.385	.000	.164	.233	.198	.017
	Age (years)					.003	.070	.002	.041	.967	-.134	.140	.003	.070
	Nurses gender					-.111	.063	-.056	-1.759	.079	-.236	.013	-.111	.063
	Nurses qualification					.030	.074	.018	.397	.692	-.117	.176	.030	.074
	Nurses specialties					.018	.012	.048	1.545	.123	-.005	.042	.018	.012
	Years of experience in a medical career					-.006	.043	-.005	-.136	.892	-.091	.079	-.006	.043
	Position Held					.112	.047	.102	2.395	.017	.020	.204	.112	.047
	Do you care about any Pharmacogenomics tests?					.084	.098	.059	.859	.391	-.108	.277	.084	.098
	Pharmacogenomics tests available at your institution					-.132	.134	-.099	-.985	.325	-.397	.132	-.132	.134
	The institution is associated with a pharmacogenomics test site.					.130	.136	.096	.959	.338	-.137	.398	.130	.136
	Presence of Pharmacogenomics request or reporting form at your institution or pharmacy					-.104	.070	-.073	-1.488	.138	-.242	.033	-.104	.070
	The number of Pharmacogenomics test					.167	.017	.480	9.951	.000	.134	.200	.167	.017

a. Dependent Variable: Nurses' practice of Pharmacogenomics, Predictors: (Constant), Location, Age (years), Site of work, Nurses gender, Nurses qualification. Nurse practice area, Years of experience, Position Held, The presence of Pharmacogenomics services, You cared any Pharmacogenomics test, Pharmacogenomics tests available at your institution, The institution has an association with a Pharmacogenomics tests site, Presence of Pharmacogenomics request or reporting form at your institution or pharmacy, The number of Pharmacogenomics test

Bootstrap for Coefficients							
Model		Bootstrap					
		B	Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
						Lower	Upper
1	(Constant)	1.572	-.008	.436	.002	.714	2.441
	Location	.023	-.001	.026	.384	-.029	.072
	Site of work	.198	.002	.022	.001	.156	.241
	Age (years)	.003	.009	.080	.965	-.130	.173
	Nurses gender	-.111	.003	.069	.106	-.245	.023
	Nurses qualification	.030	.004	.093	.757	-.146	.216
	Nurses specialties	.018	.000	.012	.132	-.006	.041
	Years of experience in a medical career	-.006	-.006	.048	.885	-.108	.084
	Position Held	.112	.002	.060	.055	-.005	.229
	Do you care about any Pharmacogenomics test	.084	-.001	.161	.622	-.231	.399
	Pharmacogenomics tests available at your institution	-.132	.006	.159	.355	-.466	.171
	The institution has an association with a Pharmacogenomics test site	.130	-.005	.176	.446	-.188	.475
	Presence of Pharmacogenomics request or reporting form at your institution or pharmacy	-.104	-.005	.087	.233	-.287	.056
	The number of Pharmacogenomics test	.167	2.421E-05	.020	.001	.129	.206

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 7: Multiple regression of Factors with the nurses' perception responsibility of Pharmacogenomics Services.

Model						Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		R	R Square	F	Sig.	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	V.I.F.
1	(Constant)	.302[b]	.091	2.835	.001[b]	2.365	.233		10.154	.000	1.907	2.823	2.365	.233
	Location					-.014	.017	-.044	-.807	.420	-.048	.020	-.014	.017
	Site of work					.050	.013	.234	3.946	.000	.025	.074	.050	.013
	Age (years)					.002	.050	.002	.032	.975	-.097	.100	.002	.050
	Nurses gender					-.068	.046	-.078	-1.491	.137	-.158	.022	-.068	.046
	Nurses qualification					-.045	.054	-.062	-.834	.405	-.150	.061	-.045	.054
	Nurses specialties					-.009	.009	-.051	-1.000	.318	-.025	.008	-.009	.009
	Years of experience in a medical career					.076	.031	.144	2.447	.015	.015	.137	.076	.031
	Position Held					.001	.034	.001	.021	.984	-.066	.067	.001	.034
	Do you care about any Pharmacogenomics tests?					.087	.071	.140	1.231	.219	-.052	.226	.087	.071
	Pharmacogenomics tests available at your institution					-.039	.097	-.066	-.399	.690	-.229	.152	-.039	.097
	The institution is associated with a pharmacogenomics test site.					-.006	.098	-.010	-.058	.954	-.199	.187	-.006	.098
	Presence of Pharmacogenomics request or reporting form at your institution or pharmacy					-.027	.050	-.043	-.534	.594	-.126	.072	-.027	.050
	The number of Pharmacogenomics test					-.002	.012	-.012	-.157	.875	-.026	.022	-.002	.012

a. Dependent Variable: Nurses' basic knowledge about Pharmacokinetics services, Predictors: (Constant), Location, Age (years), Work Site, Nurses gender, Nurse qualification. Nurse practice area, Years of experience, Position Held, The presence of Pharmacogenomics services, You cared any Pharmacogenomics test, Pharmacogenomics tests available at your institution, The institution has an association with a Pharmacogenomics tests site, Presence of Pharmacogenomics request or reporting form at your institution or pharmacy, The number of Pharmacogenomics test

Bootstrap for Coefficients							
Model		Bootstrap					
						95% Confidence Interval	
		B	Bias	Std. Error	Sig. (2-tailed)	Lower	Upper
1	(Constant)	2.365	.004	.255	.001	1.841	2.873
	Location	-.014	-.001	.016	.399	-.046	.018
	Site of work	.050	.001	.014	.002	.021	.078
	Age (years)	.002	-.006	.082	.981	-.170	.155
	Nurses gender	-.068	.000	.047	.149	-.162	.024
	Nurses qualification	-.045	-.004	.075	.566	-.189	.106
	Nurses specialties	-.009	.001	.010	.352	-.026	.012
	Years of experience in a medical career	.076	.003	.044	.089	-.006	.166
	Position Held	.001	-.003	.040	.989	-.081	.077
	Do you care about any Pharmacogenomics test	.087	.001	.086	.292	-.079	.259
	Pharmacogenomics tests available at your institution	-.039	-.007	.103	.684	-.272	.139
	The institution is associated with a pharmacogenomics test site.	-.006	.011	.105	.957	-.214	.206
	Presence of Pharmacogenomics request or reporting form at your institution or pharmacy	-.027	-.005	.052	.609	-.135	.070
	The number of Pharmacogenomics test	-.002	.001	.013	.881	-.026	.024

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

services, worked in healthcare institutions with pharmacogenomics tests, or was associated with other hospitals with pharmacogenomic services. That is expected because pharmacogenomics services are only widely implemented partially in healthcare organizations. There is a positive correlation between age and nursing qualifications. That is expected because of more aging and gaining higher qualifications and experience. The average score of nursing practice in pharmacogenomics indicates an urgent need for improvement, similar to previous studies.[29] While the best practices were observed in the mission and strategy plan of pharmacogenomics services, the lowest score was in the area of pharmacogenomics services in the pharmacy and the absence of an annual plan for pharmacogenomics services. This underscores the areas that require immediate attention and improvement, compelling us to act swiftly.

The average number of pharmacogenomics tests per hospital could have been higher, which is a significant finding. This could be related to poor practice or undocumented records of pharmacogenomics tests. Most medications involved in the pharmacogenomics services were anti-HIV and antineoplastic, different from the previous nursing home studies (20) and related to other research site settings. However, one of the medications not approved on the list for pharmacogenomics services was antidepressant medication, which represented almost 30% of the total requests for pharmacogenomics tests. This finding suggests a potential gap in the application of pharmacogenomics in the healthcare system, which needs to be addressed. The implantation of pharmacogenomics residency or training certificates is warranted.[30]

The nurse's reliance on physicians' pharmacogenomics services is a responsibility. This is because pharmaceutical care providers might not organize pharmacogenomics services. In such cases, nurses are crucial in ensuring pharmacogenomics' safe and effective use in patient care. This underscores the importance of nurses' knowledge and understanding of pharmacogenomics.

Two factors positively impacted the nursing practice of pharmacogenomics services: the site of work and the number of pharmacogenomics tests. This finding suggests that the availability of pharmacogenomics services at healthcare organizations, such as private hospitals with a good number of pharmacogenomics tests, can significantly improve the nursing practice and upgrade the system of pharmacogenomics services. This highlights the importance of infrastructure and resources in supporting the implementation of pharmacogenomics services. Interestingly, no demographic factors affected the nurses' perception of responsibility for pharmacogenomics services, indicating a consistent dedication to their profession.

LIMITATIONS

The current study had various strengths and findings, such as complete information, a musing practice of pharmacogenomics services, many samples, and a high-reliability test with validation. However, it contains several weak areas for improvement, such as not randomly selecting respondents, unequal sample sizes from each region, and missing questions about the perception of pharmacogenomics services. Overcoming all previous research might be appropriate.

CONCLUSION

The current cross-sectional study has a good calculation number sample with various age levels and high-reliability tests among various specialties of musing responders. However, the average nursing practice of pharmacogenomics could have been better. This finding suggests room for improvement in applying pharmacogenomics in nursing practice. The vision and understanding of the annual plan of pharmacogenomics was the cornerstone of low levels of pharmacogenomics services. Besides, the Department of Pharmacy Services was not involved in the practice. Sites of work such as private hospitals and several pharmacogenomics tests might affect positive musing practices. Reviewing the nursing practice of pharmacogenomics services and fully implementing pharmacogenomics practice standards is essential and highly recommended in Saudi Arabia.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Consent for Publications

Informed consent was obtained from all the participants

Ethical Approval

This research was exempted from research and ethical committee or an Institutional Review Board (I.R.B.) approval.
https://www.hhs.gov/oh\rp/regulations-and-policy/decision-charts-2018/index.html

ABBREVIATIONS

MOH: Ministry of Health; **K.S.A.:** Kingdom of Saudi Arabia; **SPSS:** Statistical Package of Social Sciences; **JASP:** Jeffery's Amazing Statistics Program; **STROBE:** Strengthening the Reporting of Observational studies in Epidemiology statement: guidelines for reporting observational studies; **VIF:** Variance Inflation Factor.

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