The Practice of Nuclear Pharmacy Services by Pharmacists in Saudi Arabia

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Received: 10-11-2020;
Accepted: 17-1-2021;

Access this article online

www.ijpcs.net

DOI: 10.5530/ijpcs.2021.10.11

ABSTRACT

Goal: In this study, we aimed to illustrate the practice of nuclear pharmacy services in Saudi Arabia. **Methods:** This is a cross-sectional study. An electronic survey was distributed to all pharmacists and pharmacy interns. Students were excluded from this study. The survey consisted of demographic data about responders and pharmacy practice aspects of nuclear pharmacy. The data were collected using the Survey Monkey system and analyzed using Microsoft Excel and Statistical Package of Social Science (SPSS). **Results:** A total of 235 pharmacists responded to the survey, with most of them coming from the southern region (82 (34.89%)), central region (49 (20.85%)), and western region (47 (20.00%)), with statistically significant differences between the regions ($p<0.001$). Almost two-thirds of the pharmacists had obtained Bachelor's degree (149 (63.40%)) and Diploma in Pharmacy (75 (31.91%)), with statistically significant differences between all the pharmaceutical degrees ($p<0.001$). Most pharmacists were staff pharmacists (119 (51.29%)) and interns (43 (18.53%)). The total average score of elements of the practice of nuclear pharmacy services was 1.69. The highest score was recorded for the element "nuclear pharmacy and facilities, equipment, and place for preparation are available" (1.79), followed by the elements "nuclear pharmacy and drug monitoring system" (1.78) and "nuclear pharmacy and radiation safety" (1.77). The average score for the element "nuclear pharmacy practice implementation" was 3.39. High scores were obtained for the element "nuclear pharmacy should be covered by health insurance" (3.79) and "nuclear pharmacy outsourcing is highly recommended" (3.67). The highest score was obtained for the element "nuclear pharmacy currently is the responsibility was a nuclear pharmacist" (4.28) and "toxicologist laboratory" (3.55). **Conclusion:** The various aspects of pharmacists based on the elements of the practice implementation of nuclear pharmacy were insufficient in the Kingdom of Saudi Arabia. Pharmacists play an active role in the nuclear pharmacy practice. Further studies on nuclear pharmacy services should be conducted thoroughly and setup strategic plan to improve nuclear pharmacy services in Saudi Arabia.

Keywords: Practice, Pharmacist, Nuclear, Pharmacy, Saudi Arabia.

INTRODUCTION

The pharmacist at the hospital pharmacy prepares, dispenses, and monitors various medications, including common drugs, chemotherapeutic agents, and radioactive medicines (radioactive pharmaceutical products). They are administered in different dosage forms, either orally or topically, and via parenteral medications. Each type of nuclear medicine has specific regulations for its process of distribution. For example, in parenteral medicines, the pharmacist should follow 797 United Stare Pharmacopeia (USP) guidelines;[1,2] for chemotherapy, the pharmacist should implement 800 USP,[3,4] and radiopharmaceutical products should be distributed through 825 USP regulations.[5] All those specific infrastructures in the pharmacy design and during drug distribution are needed. Locally, preparation and dispensing of various radioactive materials have been required by the Saudi Food and Drug Authority, and other international radiopharmaceutical preparation and dispensing and needs to be followed and implemented.[2,6-9] In addition, nuclear pharmacists dealing with radiopharmaceutical products should be registered through the National Boards of Pharmacy.[10]

The nuclear pharmacy system foundation needs a clear definition of radioactive material, vision, mission, and objectives. Moreover, all requirements of safe handling, pharmacist and patient safety considerations, and total quality management of radiopharmaceutical agents in the nuclear pharmacy practice domains must be implemented.[5,11] Various studies have been conducted to explore the general practice of nuclear medicine in multiple countries, including Saudi Arabia.[12-14] However, only a few studies are conducted on nuclear pharmacy practice.[15,16] A previous study explored the employment condition and workload of nuclear pharmacists.[17] Several other studies have investigated the participation of pharmacists in nuclear medicine services.[12,13,16,18] However, no in-depth studies are conducted on nuclear pharmacy practice either locally or in Gulf and Middle Eastern countries. Therefore, in this study, our goal was to explore the pharmacist practice of nuclear pharmacy in the Kingdom of Saudi Arabia.

METHOD

This is a cross-sectional survey conducted to analyze the practice of nuclear pharmacy by pharmacists in Saudi Arabia. This is a self-reported questionnaire distributed electronically to dentists, pharmacists (from interns to consultants), and pharmacy specialists in Saudi Arabia. All non-pharmacists and students and incomplete surveys were excluded from this study. The survey collected demographic information of the responders and their knowledge of selected nuclear pharmacy practice elements in pharmaceutical care. The nuclear pharmacy responsibility and nuclear pharmacy practice implementation. In this study, we used the 5-point Likert response scale system with close-ended questions to obtain responses. The sample size was calculated based on the available literature for a cross-sectional study; we applied a confidence level of 95% with a *z* score of 1.96 and margin of error of 5–6.5%, the population percentage of 50%, and a drop-out rate of 10%. With these parameters, the sample size was calculated as 251 to 432, with a power of study of 80%.[19-21] The minimum response rate that might be required for the calculated sample size was at least 60–70%.[21,22] The survey was distributed via WhatsApp and Telegram groups of pharmacists. A reminder message was sent once every 1-2 weeks. The expert reviewers and pilot testing validated the survey. Furthermore, various reliability tests such as McDonald's ω, Cronbach's α, Gutmann's λ2, and Gutmann's λ6 were used to test the reliability of the data. The data were captured through the Survey Monkey system, analyzed by the Statistical Package of Social Sciences (SPSS) software, Jeffery's Amazing Statistics Program (JASP), Microsoft Excel version 16. The descriptive and frequency analysis with the goodness of fit, correlation analysis, and inferential analysis of factors was conducted to analyze pharmacists' knowledge of medication safety. The STROBE (strengthening the reporting of observational studies in epidemiology statement: guidelines for reporting observational studies) guided the reporting of this study.[23,24]

RESULTS

A total of 235 pharmacists responded to the survey, with most of them coming from the southern region (82 (34.89%)), central region (49 (20.85%)), and the western region (47 (20%)), with statistically significant differences between the areas ($p<0.001$). Of them, 142 (63.96%) responders were male, and 80 (36.04%) were female, with statistically significant differences between them ($p<0.001$). Most of the responders were in the age group of 24–30 years (115 (48.94%)) and 31–35 years (57 (24.26%)), with statistically significant differences between all ages groups ($p<0.001$). Almost two-thirds of the pharmacists had obtained Bachelor's degree (149 (63.40%)) and Diploma in Pharmacy (75 (31.91%)), with statistically significant differences among all pharmaceutical degrees ($p<0.001$). Most pharmacists were staff pharmacists (119 (51.29%)) and interns (43 (18.53%)). Most of the responders had a work experience of 3 years and less (124 (52.99%)), with the majority of them having experience at the outpatient pharmacy (26 (29.89%)) and inpatient pharmacy (19 (21.84%)), with statistically significant differences between them ($p<0.001$). There was a strong positive correlation between age (years) and years of experience at pharmacy centers based on Kendall's tau_b (0.705) or Spearman's rho (0.784) values, with statistically significant differences between them ($p>0.05$). However, there is a medium negative correlation between position and years of experience at pharmacy career Kendall's tau_b (−0.505) or Spearman's rho (−0.592) with statistically significant differences between them ($p>0.05$) (Table 1 and 2).

The total average score of the element "practice of nuclear pharmacy services" was 1.69. High scores were obtained for the aspect "nuclear pharmacy and facilities, equipment, and place for preparation are available" (1.79), followed by "nuclear pharmacy and drug monitoring system" (1.78), "nuclear pharmacy and radiation safety" (1.77), and "nuclear pharmacy and chemical weapon" (1.77). However, low scores were obtained for the elements "nuclear pharmacy was the vision of nuclear pharmacy" (1.4), the mission of nuclear pharmacy (1.58), and the annual plan of nuclear pharmacy (1.61), with statistically significant differences between answers ($p<0.001$) (Table 3). The average score for the element "nuclear pharmacy practice implementation" was (3.39). High scores were obtained for the aspect "nuclear pharmacy should be covered by health insurance" (3.79), "the nuclear pharmacy outsourcing is highly recommended" (3.67), and "the clinical pharmacist had an active role in nuclear medicine departments" (3.56). However, the elements "nuclear pharmacy practice implementation scores were attendance several courses or workshops about nuclear pharmacy" (2.9) and "there are various nuclear pharmacy resources in practice available" (3.09) obtained low scores. In addition, the average score for the element "there is an electronic nuclear pharmacy connected with an electronic prescription, or computerized physicians order enter" was (3.22), with statistically significant

Table 1: Demographic social information.

Nationality	Response Count	Response Percent	*p*-value (X2)
Central area	49	20.85%	< 0.001
North area	32	13.62%	
South area	82	34.89%	
East area	25	10.64%	
West area	47	20.00%	
Answered question	**235**		
Skipped question	**0**		
Gender	**Response Count**	**Response Percent**	
Male	142	63.96%	< 0.001
Female	80	36.04%	
Answered question	**222**		
Skipped question	**13**		
Age	**Response Count**	**Response Percent**	
24-30	115	48.94%	< 0.001
31-35	57	24.26%	
36-40	34	14.47%	
41-45	10	4.26%	
46-50	11	4.68%	
> 50	8	3.40%	
Answered question	**235**		
Skipped question	**0**		

Table 2: Demographic, social information.			
Pharmacist Qualifications	**Response Count**	**Response Percent**	***p*-value (X2)**
Diploma in Pharmacy	14	5.96%	
Bachelor's in pharmacy	149	63.40%	
Master	41	17.45%	
Pharm D	75	31.91%	
Ph. D	23	9.79%	
PGY 1	10	4.26%	
PGY 2	5	2.13%	
PGY 3	6	2.55%	
Fellowship	1	0.43%	
Other (please specify)	1	0.43%	
Answered question	**235**		
Skipped question	**0**		
Position Held	**Response Count**	**Response Percent**	
Director of Pharmacy	16	6.90%	<0.001
Assistant Director of Pharmacy	18	7.76%	
Supervisor	36	15.52%	
Pharmacy staff	119	51.29%	
Pharmacy Intern	43	18.53%	
Answered question	**232**		
Skipped question	**3**		
Years of experience at Physician career	**Response Count**	**Response Percent**	
Less than one year	56	23.93%	< 001
1-3	68	29.06%	
4-6	45	19.23%	
7-9	32	13.68%	
10-12	13	5.56%	
>12	20	8.55%	
Answered question	**234**		
Skipped question	**1**		
The practice area	**Response Count**	**Response Percent**	
Inpatient Pharmacy	19	21.84%	< 001
Outpatient Pharmacy	26	29.89%	
Satellite Pharmacy	1	1.15%	
Narcotics and Controlled	3	3.45%	
Extemporaneous Preparation	1	1.15%	
Clinical Pharmacy	10	11.49%	
Inventory Control	1	1.15%	
Drug Information	2	2.30%	
IV admixture	1	1.15%	
Community pharmacy	9	10.34%	
Pharmaceutical companies	7	8.05%	
Other (please specify)	7	8.05%	
Answered question	**87**		
Skipped question	**148**		

differences between the responses ($p<0.001$) (Table 4). The scores for the elements "nuclear pharmacy (to authorities) is currently the responsibility of a nuclear pharmacist" (4.28), and for "toxicologist laboratory," it was (3.55). In contrast, the lowest score was nuclear medicine doctor (2.38), with a statistically significant difference between all answers ($p<0.001$) (Table 5). The majority of the responders work in a nuclear pharmacy (208 (89.27%)). However, there were no statically significant differences between all responders who worked or did not work in nuclear pharmacy practice ($p>0.05$). The reliability test of McDonald's ω, (0.917), Cronbach's α(0.943), Gutmann's λ2 (0.950), and Gutmann's λ6 (0.977).

Factors (average scores) influencing the items for nuclear pharmacy practice and nuclear pharmacy implementation

Various factors might influence the items for nuclear pharmacy practice in the Kingdom of Saudi Arabia. For example, the location of the pharmacist affected the knowledge about nuclear pharmacy implementation, with the western region scoring the lowest average (1.3313). There were statically significant differences between the responses from the different areas ($p=0.001$). There were no statically significant differences found in other age groups ($p=0.075$), gender ($p=0.617$), position ($p=0.391$), and years of experience ($p=0.336$). Furthermore, various factors might influence the nuclear pharmacy implementation in the Kingdom of Saudi Arabia. For example, different locations affected implementation knowledge, with the highest average score (3.8537) with statically significant differences between them ($p=0.001$). The implementation of nuclear pharmacy was affected by age groups (24–30 years showed the lowest average score (3.2058) and 31–36 years with the score of (3.2582), with statically significant differences them ($p=0.000$). Gender of the pharmacist affected the score for nuclear pharmacy implementation, with the highest score obtained for females (3.5705), with statistically significant differences ($p=0.04$). The position of the pharmacist affected the implementation of nuclear pharmacy; the pharmacy supervisor had the highest average score (3.8402), with statically significant differences ($p=0.003$). Years of work experience also affected the nuclear pharmacy implementation, with pharmacists with 10–12 years of experience having the highest average score (4.3765), with statically significant differences between them ($p=0.003$) (Table 6).

In this study, we analyzed the relationship between the practice aspect of nuclear

Table 3: The aspects for nuclear pharmacy practice.

	No activity had been implemented		It was formally discussed and considered, but it was not implemented		It is partially implemented in hospitals for some or all areas, patients, drugs, staff		It is fully implemented in the hospital for some areas, patients, drugs, and staff		It is fully implemented throughout the hospital for all patients, drugs, and staff		Total	Weighted Average	*p*-value
The vision of nuclear pharmacy	78.72%	185	10.64%	25	5.11%	12	2.98%	7	2.55%	6	235	1.4	<0.001
Mission of Nuclear pharmacy	62.66%	146	25.75%	60	4.72%	11	4.29%	10	2.58%	6	233	1.58	<0.001
The strategic plan of nuclear pharmacy	65.67%	153	17.17%	40	7.73%	18	6.01%	14	3.43%	8	233	1.64	<0.001
The annual plan of nuclear pharmacy	63.09%	147	22.75%	53	6.87%	16	4.29%	10	3.00%	7	233	1.61	<0.001
Policy and procedure of nuclear pharmacy	64.94%	150	15.15%	35	8.23%	19	7.36%	17	4.33%	10	231	1.71	<0.001
Nuclear pharmacy competency	61.47%	142	22.08%	51	6.49%	15	7.36%	17	2.60%	6	231	1.68	<0.001
Nuclear pharmacy and quality management	62.34%	144	19.91%	46	7.36%	17	6.93%	16	3.46%	8	231	1.69	<0.001
Nuclear pharmacy and education and training program	62.88%	144	20.96%	48	4.37%	10	8.73%	20	3.06%	7	229	1.68	<0.001
Nuclear pharmacy and medications errors system	60.78%	141	21.55%	50	8.19%	19	5.60%	13	3.88%	9	232	1.7	<0.001
Nuclear pharmacy and adverse drug reactions	62.50%	145	17.67%	41	5.60%	13	9.91%	23	4.31%	10	232	1.76	<0.001
Nuclear pharmacy and drug quality reporting systems	60.17%	139	24.24%	56	7.79%	18	4.33%	10	3.46%	8	231	1.67	<0.001
Nuclear pharmacy and potential drug-drug interaction	63.64%	147	17.32%	40	3.90%	9	10.82%	25	4.33%	10	231	1.75	<0.001
Nuclear pharmacy and poisoning	58.44%	135	24.68%	57	7.79%	18	5.19%	12	3.90%	9	231	1.71	<0.001
Nuclear pharmacy and chemical weapon	63.32%	145	14.41%	33	8.73%	20	8.73%	20	4.80%	11	229	1.77	<0.001
Nuclear pharmacy and research	60.94%	142	19.31%	45	9.87%	23	5.58%	13	4.29%	10	233	1.73	<0.001
Nuclear pharmacy and radiation safety	62.23%	145	17.60%	41	6.87%	16	7.30%	17	6.01%	14	233	1.77	<0.001
Nuclear pharmacy and facilities, equipment, and place for preparation	57.51%	134	22.75%	53	8.15%	19	6.44%	15	5.15%	12	233	1.79	<0.001
Nuclear pharmacy and drug monitoring system	60.17%	139	21.21%	49	5.63%	13	6.49%	15	6.49%	15	231	1.78	<0.001
											Answered	**235**	
											Skipped	**0**	

Table 4: Nuclear pharmacy practice implementation.

	Strongly disagree		Disagree		Uncertain		Agree		Strongly agree		Total	Weighted Average	
The pharmacist share in nuclear medicine committee	10.68%	25	9.83%	23	26.07%	61	23.08%	54	30.34%	71	234	3.53	<0.001
The pharmacist always a staff member of nuclear medicine departments	6.90%	16	9.91%	23	33.62%	78	21.98%	51	27.59%	64	232	3.53	<0.001
The pharmacist had clear job descriptions in nuclear medicine departments or pharmacy department	9.96%	23	10.39%	24	32.03%	74	21.21%	49	26.41%	61	231	3.44	<0.001
The clinical pharmacist had active role in nuclear medicine departments	8.70%	20	9.13%	21	27.83%	64	26.09%	60	28.26%	65	230	3.56	<0.001
There is documentation of potential impact and outcomes with nuclear medicine	8.19%	19	11.64%	27	33.19%	77	23.71%	55	23.28%	54	232	3.42	<0.001
I attended several courses or workshops about nuclear pharmacy	22.41%	52	17.24%	40	25.00%	58	18.97%	44	16.38%	38	232	2.9	0.192
There is electronic nuclear pharmacy	12.50%	29	9.91%	23	39.22%	91	19.83%	46	18.53%	43	232	3.22	<0.001
There are various of nuclear pharmacy resources in the practice	14.96%	35	15.81%	37	32.48%	76	18.38%	43	18.38%	43	234	3.09	<0.001
The nuclear medicine departments are responsible of procurement, preparation, and dispensing radio pharmaceutical products	9.01%	21	13.73%	32	37.34%	87	19.31%	45	20.60%	48	233	3.29	<0.001
The pharmacy department are responsible of procurement, preparation, and dispensing radio pharmaceutical products	9.83%	23	11.54%	27	37.18%	87	22.65%	53	18.80%	44	234	3.29	<0.001
The nuclear pharmacy should be covered by health insurance	5.17%	12	8.62%	20	25.43%	59	23.71%	55	37.07%	86	232	3.79	<0.001
I think the nuclear pharmacy outsourcing is high recommended	6.87%	16	9.87%	23	25.75%	60	24.46%	57	33.05%	77	233	3.67	<0.001
											Answered	**235**	
											Skipped	**0**	

pharmacy and factors affecting it, such as location, age (years), gender, position held, and years of experiences of the pharmacist at the pharmacy center. This relationship was demonstrated through a multiple regression model. In the model, the practice aspect of nuclear pharmacy was considered the dependent variable, and factors affecting it were regarded as an expletory variable. Our analysis showed a weak relationship (R=0.261 with p=0.010) between the implementation of nuclear pharmacy and factors affecting it. However, only two factors affected the responses: first, the location of the pharmacist explained 17.2% (p=0.010) of the variation in the negative relationship, and second, age of the pharmacists explained 41.6% (p=0.000) of the variation in the positive relationship between the practice of nuclear pharmacy implementation with a statistically significant (p<0.05) through multiple regression model. The bootstrap model confirmed it. The relationship between the practice aspect of nuclear pharmacy and the two factors was verified by the nonexistence of multi-collinearity with location factor (VIF=1.053) and age (VIF=3.11), all of them almost less than three or less than five[25-27] (Table 7).

Next, we studied the relationship between the practice of implementing nuclear pharmacy and factors affecting it, such as location, age (years), gender, position held, and years of pharmacist experience at the pharmacy center. This relationship was demonstrated through the multiple regression model by considering the implementation of nuclear pharmacy as the -dependent variable and factors affecting it as the expletory variable. Our analysis showed a weak relationship (R=0.373 with

Table 5: The nuclear pharmacy (to authorities) currently is the responsibility of the following.

	Strongly disagree		Disagree		Uncertain		Agree		Strongly agree		Total	Weighted Average	
Nuclear medicine Doctors	47.41%	110	11.21%	26	15.52%	36	8.19%	19	17.67%	41	232	2.38	<0.001
Nuclear Pharmacist	3.86%	9	2.58%	6	13.30%	31	21.89%	51	58.37%	136	233	4.28	<0.001
Pharmacy technicians	12.12%	28	7.36%	17	28.14%	65	21.21%	49	31.17%	72	231	3.52	<0.001
Nuclear Nurses	12.55%	29	11.69%	27	31.60%	73	16.45%	38	27.71%	64	231	3.35	<0.001
Toxicology laboratories	7.36%	17	8.66%	20	33.33%	77	22.94%	53	27.71%	64	231	3.55	<0.001
											Answered	**235**	
											Skipped	**0**	

Table 6: Factors (average scores) influencing the items for nuclear pharmacy practice and nuclear pharmacy implementation.

		Aspects for nuclear pharmacy *practice*							nuclear pharmacy implementation						
	Factors	N	Average scores	Std. D	Median	Lower Bound	Upper Bound	*P*-value	N	Average scores	Std. D	Median	Lower Bound	Upper Bound	*P*-value
Region	Central	46	1.7105	.99515	1.3611	1.4149	2.0060	0.001	46	3.0703	.94990	3.0417	2.7882	3.3524	0.001
	North	28	2.0754	.78687	2.1667	1.7703	2.3805		28	3.4665	.88575	3.5000	3.1230	3.8099	
	South	76	1.7615	.94069	1.2778	1.5465	1.9764		76	3.3056	.74413	3.2083	3.1356	3.4757	
	East	25	1.9350	.92176	1.5000	1.5546	2.3155		25	3.2158	.85364	3.0833	2.8634	3.5681	
	West	44	1.3313*	.660	1.0556	1.0843	1.5782		44	3.8537*	1.21370	3.8333	3.4847	4.2227	
	Total	219							219						
Age	24-30	112	1.6460	.87187	1.1667	1.4828	1.8093	0.075	112	3.2058*	.76807	3.1333	3.0620	3.3496	0.000
	31-35	52	1.6375	.59162	1.4722	1.4728	1.8022		52	3.2582*	.90617	3.1250	3.0059	3.5104	
	36-40	30	2.1223	1.19088	1.6111	1.6776	2.5669		30	3.7419	1.02267	3.6591	3.3600	4.1238	
	41-45	9	1.6358	.81560	1.1667	1.0089	2.2627		9	3.5833	1.62660	4.0000	2.3330	4.8337	
	46-50	8	1.8472	1.44894	1.1667	.6359	3.0586		8	3.8229	1.45599	4.2500	2.6057	5.0402	
	> 50	8	1.8681	1.61779	1.0000	.5156	3.2206		8	4.4896	.93694	5.0000	3.7063	5.2729	
	Total	219							219						
Gender	Male	139	1.6713	.83904	1.3333	1.5306	1.8120	0.617	139	3.2651	.87782	3.1667	3.1178	3.4123	0.04
	Female	80	1.8164	1.06534	1.3333	1.5793	2.0535		80	3.5705	1.05936	3.5000	3.3347	3.8062	
	Total	219							219						
Employment	Director of Pharmacy	15	1.2526	.33080	1.0667	1.0694	1.4358	0.391	15	3.4960	1.14681	3.3333	2.8609	4.1310	0.003
	Assistant director of Pharmacy	16	1.4516	.38621	1.3889	1.2458	1.6574		16	3.3755	1.23588	3.0417	2.7169	4.0340	
	Supervisor	33	2.2586	1.39862	1.9444	1.7626	2.7545		33	3.8402*	1.03108	3.9167	3.4746	4.2058	
	Pharmacy staff	113	1.6401	.75537	1.3333	1.4994	1.7809		113	3.2849	.89960	3.0833	3.1172	3.4526	
	Intern	42	1.8032	1.01934	1.1667	1.4855	2.1208		42	3.2170	.77176	3.2083	2.9765	3.4575	
	Total	219							219						
Experiences	<1	55	1.7881	1.01949	1.0556	1.5125	2.0637	0.336	55	3.3606	.78617	3.3333	3.1481	3.5731	0.001
	1-3	64	1.7388	.76370	1.5000	1.5480	1.9296		64	3.2225	.89886	3.2159	2.9980	3.4471	
	4-6	43	1.4997	.60201	1.3333	1.3144	1.6850		43	3.1989	.75534	3.0000	2.9665	3.4314	
	7-9	27	1.8744	1.09126	1.4444	1.4427	2.3061		27	3.4279	1.09603	3.2727	2.9943	3.8615	
	10-12	13	1.6797	1.00756	1.2222	1.0709	2.2886		13	4.3765*	.98215	5.0000	3.7829	4.9700	
	>12	17	1.8268	1.44536	1.0000	1.0837	2.5699		17	3.6119	1.40944	3.5000	2.8872	4.3365	
	Total	219							219						

Table 7: Multiple regression of Factors with the practice aspect of nuclear pharmacy.[a]

Model		R	R Square	F	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
						B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.261[b]	.068	3.108	.010[b]	1.456	.378	-.172-	3.852	.000	.711	2.200		
	Location					-.116-	.046	.328	-2.540-	.012	-.207-	-.026-	.950	1.053
	Age (years)					.231	.082	.055	2.810	.005	.069	.393	.322	3.110
	Pharmacist gender					.106	.132	.108	.805	.422	-.153-	.365	.936	1.069
	Position Held					.093	.066	-.198-	1.414	.159	-.037-	.222	.755	1.324
	Years of experience at pharmacy career					-.122-	.074		-1.641-	.102	-.268-	.025	.302	3.312

a. Dependent Variable: practice aspect of nuclear pharmacy, [b] Predictors: (Constant), Location, Age (years), Pharmacist gender, Position Held, and Years of experiences at pharmacy career.

Bootstrap for Coefficients							
Model		B	Bootstrap[a]				
			Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
						Lower	Upper
1	(Constant)	1.456	.003	.331	.001	.799	2.105
	Location	-.116-	.000	.049	.023	-.214-	-.022-
	Age (years)	.231	-.001-	.087	.008	.071	.414
	Pharmacist gender	.106	-.005-	.132	.428	-.165-	.356
	Position Held	.093	.001	.053	.076	-.018-	.201
	Years of experience at pharmacy career	-.122-	.001	.068	.081	-.244-	.028

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

p=0.000) between the implementation of nuclear pharmacy and factors affecting it. However, three factors were found to affect the responses: first, location of the pharmacists explained 16.9% (p=0.010) of the variation; second, age explained 41.6% (p=0.000) of the positive relationship; and finally, years of work experience explained 25.7% (p=0.27) of the negative association in the practice of implementation of nuclear pharmacy with a statistically significant (p<0.05) through multiple regression model and confirmed by Bootstrap model. The relationship between the practice aspect of nuclear pharmacy and two factors verified by the nonexistence of multicollinearity with location factor (Variance Inflation factors VIF=1.053), age (VIF=3.11), and experiences (VIF=3.312) all of them almost less than three or less than five[25-27] (Table 8).

DISCUSSION

The practice of nuclear medicine was started at a single center in 1983, which expanded to more than 50 healthcare organizations in Saudi Arabia.[12,13,18] Nuclear medicine is mainly used for diagnostic procedures and the management of various diseases.[12,13,18] In contrast, the nuclear pharmacy includes procurement, storage, preparation of parenteral or nonparenteral radioactive medications, and follow-up with emergency safety and efficacy. Various physicians and technicians have specialized in nuclear medicine. However, only a few pharmacists work in the department of nuclear medicine in Saudi Arabia,[12,13] which is lower than in other countries.[12] Therefore, it was unclear the activities of pharmacists at nuclear medicine or nuclear pharmacy practice. Thus, in this study, we aimed to declare the practice of nuclear pharmacy at healthcare centers. This cross-sectional study was performed with a target-convenient sample through a validated electronic survey and high-reliability scores. The sample consisted of males from the southern region of Saudi Arabia based on the survey distributed by participant's authors. The responders were young with less work experience and low position held. However, the young pharmacists responded to the research survey better than that the old pharmacists. Usually, the new pharmacist graduate worked at outpatient and inpatient pharmacies as results explored.

According to the results of this study, the implementation of nuclear pharmacy practice was deficient. The element with the highest score of practice was the preparation area and facilities. The pharmacy services established the appropriate place for drug distribution. They did not provide nuclear medication at many healthcare organizations due to the expensive radiopharmaceutical products or the absence of trained nuclear pharmacists.[28] The pharmacist seldom monitors radioactive safety, and drug-related problems as the majority of the healthcare centers do not provide nuclear pharmacies. The vision, mission, and annual plan did not exist at most healthcare centers because the nuclear pharmacy domains were still not established.[11] Another very critical foundation activity was asked the pharmacist in the survey about nuclear pharmacy performance. According to our results, almost two-thirds of the responders had no experience practicing in the nuclear pharmacy field. There are no differences in answering the survey between practice or did not practice nuclear pharmacy. The pharmacists might be practice in reality. There are no actual nuclear pharmacy services, the pharmacist did not understand the survey very well, or the responders did not answer properly. The finding showed that pharmacists are willing to involve as active members at nuclear pharmacy services to provide full clinical and distributive nuclear pharmacy activities.[29,30,31] Moreover,

Table 8: Multiple regression of Factors with the practice of nuclear pharmacy implementation.[a]

Model		R	R Square	F	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
						B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.373[b]	.139	6.883	.000[b]	2.835	.374		7.572	.000	2.097	3.573		
	Location					.118	.045	.169	2.595	.010	.028	.207	.950	1.053
	Age (years)					.303	.082	.416	3.712	.000	.142	.463	.322	3.110
	Pharmacist gender					.181	.130	.091	1.387	.167	-.076-	.438	.936	1.069
	Position Held					-.057-	.065	-.064-	-.881-	.380	-.185-	.071	.755	1.324
	Years of experience at pharmacy career					-.163-	.074	-.257-	-2.221-	.027	-.308-	-.018-	.302	3.312

a. Dependent Variable: practice aspect of nuclear pharmacy, [b] Predictors: (Constant), Location, Age (years), Pharmacist gender, Position Held, and Years of experiences at pharmacy career.

Bootstrap for Coefficients							
Model		B	Bootstrap[a]				
			Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
						Lower	Upper
1	(Constant)	2.835	.002	.451	.001	1.949	3.721
	Location	.118	-.002-	.046	.008	.023	.205
	Age (years)	.303	-.001-	.080	.001	.141	.456
	Pharmacist gender	.181	.001	.139	.205	-.088-	.459
	Position Held	-.057-	.000	.072	.422	-.200-	.088
	Years of experience at pharmacy career	-.163-	.001	.072	.021	-.308-	-.028-

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

to successfully operate nuclear pharmacy services, two main things need to be done in nuclear pharmacy practice: nuclear pharmacy utilization and outsourcing. These aspects were beneficial and might be cheaper than established inside healthcare organizations.[32,33] Some of the crucial elements were not implemented in the nuclear pharmacy practice, such as education and training for nuclear pharmacy. The pharmacy resources are not available at most healthcare centers, and computerized physicians order entry of the nuclear pharmacy services or radioactive drug, which were consisted of a previous nuclear medicine study finding.[13] Therefore, the responders are highly recommended to be pharmacists or clinical pharmacists responsible for nuclear pharmacy practice. At the same time, the responsibility of the nuclear pharmacy should be withdrawn from physicians because the pharmacist should be more familiar with radiopharmaceutical drugs from their procurement, preparation, and dispensing stages.[34] Moreover, nuclear pharmacists provide clinical activities to the patients.[29-31,33,35-37] Despite all the previous positive answers, the majority of the responders of nuclear pharmacy practice did not participate in this study. Thus, our results showed no difference between the practice of nuclear pharmacy services because of the small sample size.

Many factors affected nuclear pharmacy practice. For instance, location, age, gender, position, and years of experience. All these factors did not affect nuclear pharmacy practice in a statistically significant manner ($p>0.05$). However, one factor that might affect the practice of nuclear pharmacy services was the location of the pharmacist. The western region was affected by nuclear pharmacy practice because several nuclear pharmacy services are not widely practiced in a particular area. On the contrary, five factors might affect the implementation of pharmacy practice aspect. First, the western region was significantly affected responders answered. That is related to some parts of nuclear pharmacy practice not being done, the responders not understanding the questions or unclear justifications. Second, the young pharmacists might affect the nuclear pharmacy implementation because they do not have enough experience in the field of nuclear pharmacy practice. Third, females agreed more on nuclear pharmacy practice than males because females primarily practice in this field than males. Fourth, the supervisor (position held) had the highest score of nuclear pharmacy implementation, which is expected because they had more experience in pharmacy administration or pharmacy quality management during accreditation of legal bodies. Finally, work experience is a critical factor that affects the nuclear pharmacy practice. Especially in our study, 10–12 years of experience needed more practice in nuclear pharmacy.

The pharmacy aspect of nuclear pharmacy showed a significant positive correlation with the location and age of the pharmacists, which is expected. The changes in the area from one region to another will increase practice experiences because of the nuclear pharmacy services offered at this location or region. In addition, the age of the pharmacist had a positive correlation with the responses. Higher age showed higher scores in practice, and they had more training and experience. Therefore, the nuclear pharmacy practice implementation is affected by two factors: location and age of the pharmacist. Moreover, several years of experience is an additional factor that affected the responses.

LIMITATIONS

This study provides critical information about nuclear pharmacy implementation.

However, there were some limitations. First, the calculated sample size did not reach an optimal level. Further analysis with at least 380–400 responders is highly recommended. Second, the method of sampling was the convenient sample due to which the sample contained unequal distribution of responders per geographic location, and there was unequal age distribution. Third, the number of male and female responders was unequal. Fourth, most of the responders were young who had recently graduated with little experience in nuclear pharmacy practice. As a result, our results did not reflect pharmacists with different levels of experience, age groups, or positions. Further studies with comparable demographic data are highly recommended. Finally, literature is scarce concerning research about nuclear pharmacy practice, and therefore, we could compare our data with previous investigations.

CONCLUSION

The practice of nuclear pharmacy in Saudi Arabia is poor, which could be due to various factors that influenced the implementation of nuclear pharmacy, such as young age. On the other hand, more experience or higher position as the supervisor showed good pharmacists' knowledge in terms of practice. Therefore, nuclear pharmacists should be increased and involved in nuclear medicine with a clear job description. Further in-depth survey about nuclear pharmacy services is required, and strategic plans should be set up to improve nuclear pharmacy practice in Saudi Arabia.

ACKNOWLEDGEMENT

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

Funding

None

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 (IRB) approval.

https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html

ABBREVIATIONS

KSA: Kingdom of Saudi Arabia; **UPS:** United Stare Pharmacopeia; **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.

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