

Nurses' Knowledge of Pharmacokinetics Services in Saudi Arabia

Mohamed Soliman Imam, Bcs. Pharm, MSc. Clin Pharm
Department of Clinical Pharmacy, College of Pharmacy, Shaqra University, Shaqra, SAUDI ARABIA.

Department of Clinical Pharmacy, National Cancer Institute, Cairo University, Fom El Khalig Square, Kasr Al-Aini Street, Cairo, EGYPT.

Yousef Ahmed Alomi*,  BSc. Pharm, MSc. Clin Pharm, BCPS, BCNSP, DIBA, CDE
Critical Care Clinical Pharmacists, TPN Clinical Pharmacist, Freelancer Business Planner, Content Editor, and Data Analyst, Riyadh, SAUDI ARABIA.

Abeer Alatawi, Ph D
Faculty of Nursing, University of Tabuk, Tabuk, SAUDI ARABIA.

Khulud Salem Alotaibi, Pharm D
King Khalid University Hospital, King Saud University, Riyadh, SAUDI ARABIA.

Hadeel Saad Althagafi, Pharm D
College of Pharmacy, Taif University, Taif, SAUDI ARABIA.

Fahad Mofareh Alosaimi, Pharm D
College of Pharmacy, Taif University, Taif, SAUDI ARABIA.

Lujain Shbeir, Pharm D
College of Pharmacy, Princess Nourah bint Abdulrahman University, Riyadh, SAUDI ARABIA.

Reema Alfahaid, Pharm D
College of Pharmacy, Princess Nourah bint Abdulrahman University, Riyadh, SAUDI ARABIA.

Correspondence:

Dr. Yousef Ahmed Alomi, BSc. Pharm, MSc. Clin Pharm, BCPS, BCNSP, DIBA, CDE, Critical Care Clinical Nurses, TPN Clinical Pharmacist, Freelancer Business Planner, Content Editor, and Data Analyst, P.O.BOX 100, Riyadh 11392, SAUDI ARABIA

E-mail: yalomi@gmail.com

Received: 12-04-2023;

Accepted: 17-06-2023.

Copyright: © the author(s), publisher and licensee Pharmacology, Toxicology and Biomedical Reports. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited. This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License

Access this article online



www.ptbreports.org

DOI:
10.5530/PTB.2024.10.1

ABSTRACT

Objectives: To explore the nurses' basic knowledge of Pharmacokinetics services in Saudi Arabia.

Materials and Methods: It analyzes a cross-sectional survey that discusses the nurses' basic knowledge of some items for Pharmacokinetics services in Saudi Arabia. The survey comprised respondents' demographic information about the assessment of pharmacokinetics services, their knowledge of nurses, and the resources of pharmacokinetics services used by nurses. The 5-point Likert response scale system was used with closed-ended questions. 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 λ_2 , and Gutmann's λ_6 been done with the study. Furthermore, the nurses' basic knowledge of Pharmacokinetics services was analyzed 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 408 nurses responded to the questionnaire. Of them, almost two-thirds responded from the central region (140 (34.31%) and southern areas (119 (29.17%)), with statistically significant differences between the provinces ($p=0.000$). Most of the responders were from Ministry of Health (M.O.H.) hospitals (267 (65.44%)), with a statistically significant difference between working sites ($p=0.000$). Males responded more than females (210 (52.24%) versus 192 (47.76%)), with statistically significant differences between all levels ($p=0.000$). Most of the responders were in the age group of 36-45 years (227 (55.91%) and 46-55 years (99 (24.38%)), with statistically significant differences between all age groups ($p=0.000$). The majority of responders, 372 (91.85%), worked at an organization that had drug levels form, with most of them, 378 (93.33%), ever requesting Pharmacokinetics services or drug levels with statistically significant differences between all answers ($p=0.000$). The average score of basic knowledge of nurses about the Pharmacokinetics Services was (3.48). The element "Have you ever heard about the concept of Pharmacokinetics (drug levels)?" obtained the highest score (3.88). The aspect "heard about the concept of therapeutic drug monitoring" (3.71). In contrast, the lowest score was obtained for the element "In Saudi Arabia is there a Pharmacokinetics service" (3.12). Followed the score of the component "In Saudi Arabia, are there legal provisions in the medicines act that provide for Pharmacokinetics activities" (3.13), and for the part "In Saudi Arabia, is there an official standardized form for requesting Pharmacokinetics services or drug levels" was (3.13), with a statistically significant difference between the responses ($p<0.000$). The most resources for Pharmacokinetics Services were the Internet (e.g., Google searches, WebMD, etc.) 261 (64.13%), Medical association literature/guidelines/recommendations 248 (60.93%). **Conclusion:** The nursing Knowledge of pharmacokinetics services or drug levels was acceptable. The majority of healthcare organizations had pharmacokinetics services. However, the pharmacokinetics standards and legality of pharmacokinetics services are missing from nursing knowledge. Most of the pharmacokinetics references were from the internet and Medical associations and guidelines. The knowledge of pharmacokinetics services should be reviewed and scandalized. Targeting education and training in pharmacokinetics is optimal demand for nursing workforces.

Keywords: Nurses, Knowledge, Pharmacokinetics, Drug level, Saudi Arabia.

INTRODUCTION

The pharmacokinetics services or drug level determination and monitoring were established in the United States of America and Saudi Arabia in the 1960s and 1980s, respectively.¹ King Faisal Specialties and Research Center, one of the oldest hospitals, started those services with the responsibility of the clinical pharmacist team. Then, Pharmacokinetics expanded the overall hospital system in Saudi Arabia. The pharmacokinetics services need physicians, nurses, and clinical pharmacists. Each of them had a different job description. For example, physicians prescribe medication that has a narrow therapeutic.² The nurse withdraws the drug blood sample, sends it to the hospital

laboratory, and receives the results with complete documentation in the patient profile. The clinical pharmacist sets up the initial dosing to determine the appropriate sampling time before and after starting the drug dosing, interprets the results, and recommends adjusting the dose based on drug levels and patient status. The nurse should be familiar with medication that needs drug monitoring of drug levels and have complete knowledge about pharmacokinetics services as team members inside the hospital. Various studies discussed physicians' and pharmacists' knowledge of pharmacokinetics services. However, publications about nursing knowledge of pharmacokinetics services in Saudi Arabia,

Gulf countries, and Arabic countries have yet to be found.³⁻¹⁰ The current research aims to explore the nursing knowledge of pharmacokinetic services in Saudi Arabia.

MATERIALS AND METHODS

It analyzes a cross-sectional survey that discussed the nurses' basic knowledge of some items for pharmacokinetics services 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 assessing the pharmacokinetics services knowledge of nurses. In addition to the resources of pharmacokinetics services nurses use.³⁻¹⁰ 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%.¹¹⁻¹³ The response rate required for the calculated sample size is at least 60-70% and above.¹⁴ 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 λ_2 , and Gutmann's λ_6 been done with the study. The data analysis of nurses' knowledge of pharmacokinetics 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 pharmacokinetics services at an institution 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.¹⁵

RESULTS

A total number of 408 nurses responded to the questionnaire. Of them, almost two-thirds responded from the central region (140 (34.31%)) and southern regions (119 (29.17%)), with statistically significant differences between the provinces ($p=0.000$). Most of the responders were from Ministry of Health (M.O.H.) hospitals (267 (65.44%)), with a statistically significant difference between working sites ($p=0.000$). Males responded more than females (210 (52.24%)) versus 192 (47.76%), with statistically significant differences between all levels ($p=0.000$). Most of the responders were in the age group of 36-45 years (227 (55.91%)) and 46-55 years (99 (24.38%)), with statistically significant differences between all age groups ($p=0.000$). Most of the nurses had a bachelor's degree (372 (91.63%)), with statistically significant differences between all levels ($p=0.000$). Most of the responders worked as nursing staff (342 (84.44%)), with a statistically significant difference between positions ($p=0.000$). Most nurses had a work experience of 4-6 years (194 (47.67%)) and 6-9 years (126 (30.96%)), with a statistically significant difference between years of experience ($p=0.000$). Most of nurses's specialties was emergency (58 ((14.46%)), critical care (58 ((14.46%)), family medicine (49 ((12.22%)), and Anesthesia (48 ((11.97%)) with statistically significant differences between all specialties ($p=0.000$). The majority of responders, 372 (91.85%), worked at an organization that had drug levels form, with most of them, 378 (93.33%), ever requesting Pharmacokinetics services

or drug levels with statistically significant differences between all answers ($p=0.000$). There are non-statistically significant correlations between all demographic variables ($p>0.05$) (Tables 1 and 2).

Table 1: Demographic, social information.				
Nationality	Response Count	Response Percent	p-value (X2)	
Central area	140	34.31%	0.000	
North area	86	21.08%		
South area	119	29.17%		
East area	48	11.76%		
West area	15	3.68%		
Answered question	408			
Skipped question	0			
Site of work	Response Count	Response Percent	p-value (X2)	
M.O.H. Hospitals	267	65.44%	0.000	
Military Hospitals	30	7.35%		
National Gaurd Hospital	46	11.27%		
Security Forces Hospitals	26	6.37%		
University Hospital	3	0.74%		
M.O.H. Primary Care Centers	1	0.25%		
Private Hospitals	23	5.64%		
Private Ambulatory Care Clinics	9	2.21%		
Private Primary Healthcare Center	3	0.74%		
Answered question	408			
Skipped question	0			
Gender	Response Count	Response Percent		p-value (X2)
Male	210	52.24%		0.000
Female	192	47.76%		
Answered question	402			
Skipped question	6			
Age	Response Count	Response Percent	p-value (X2)	
24-35	76	18.72%	0.000	
36-45	227	55.91%		
46-55	99	24.38%		
>55	4	0.99%		
Answered question	406			
Skipped question	2			

Table 2: Demographic, social information.			
Nurses Qualifications	Response Count	Response Percent	p-value (X2)
Diploma	10	2.46%	0.000
Bachelor nursing	372	91.63%	
Master	20	4.93%	
Ph D	4	0.99%	
Answered question	406		
Skipped question	2		

Position Held	Response Count	Response Percent		
Director of the Nursing Department	18	4.44%	0.000	
Assistant director of nursing department	25	6.17%		
Supervisor	20	4.94%		
Nursing staff	342	84.44%		
Answered question	405			
Skipped question	3			
Years of experience in a nursing career	Response Count	Response Percent		
< 1	15	3.69%	0.000	
1-3	38	9.34%		
4-6	194	47.67%		
6-9	126	30.96%		
> 9	34	8.35%		
Answered question	407			
Skipped question	1			
The practice area	Response Count	Response Percent		
Medical	41	10.22%	0.000	
Surgical	45	11.22%		
Pediatrics	39	9.73%		
Critical care	58	14.46%		
Emergency	58	14.46%		
Anesthesia	48	11.97%		
Obstetric and Gynecology	18	4.49%		
Psychiatry	18	4.49%		
Family medicine	49	12.22%		
Ambulatory care clinic	7	1.75%		
Nephrology	11	2.74%		
Cardiology	6	1.50%		
Hematology/Oncology	1	0.25%		
Administration	1	0.25%		
Education/ Training	1	0.25%		
Answered question	401			
Skipped question	7			
Do you have drug levels at your institution?	Response Count	Response Percent		p-value (X2)
Yes	372	91.85%		0.000
No	21	5.19%		
I do not know	12	2.96%		
Answered question	405			
Skipped question	3			
Have you ever requested any Pharmacokinetics services or drug level?	Response Count	Response Percent		
Yes	378	93.33%	0.000	
No	22	5.43%		
I do not know	5	1.23%		
Answered question	405			
Skipped question	3			

The average score of basic knowledge of nurses about the Pharmacokinetics Services was (3.48). The element "Have you ever heard about the concept of Pharmacokinetics (drug levels)?" obtained the highest score (3.88). The aspect "heard about the concept of therapeutic drug monitoring" (3.71). The element "know what is the time within which you should request drug levels" was (3.71). In contrast, the lowest score was obtained for the element "In Saudi Arabia is there a Pharmacokinetics service" (3.12). Followed the score of the component "In Saudi Arabia, are there legal provisions in the medicines act that provide for Pharmacokinetics activities" (3.13), and for the part "In Saudi Arabia, is there an official standardized form for requesting Pharmacokinetics services or drug levels" was (3.13), with a statistically significant difference between the responses ($p < 0.000$). All aspects of the perception of nurses about basic knowledge of nurses about the Pharmacokinetics Services were statistically substantial between responses ($p < 0.000$) (Table 3). The most resources for Pharmacokinetics Services were the Internet (e.g., Google searches, WebMD, etc.) 261 (64.13%), Medical association literature/guidelines/recommendations 248 (60.93%). You were followed by the Drug information resources (Micromedex, Lexicomp, Epocrate, ...) 18 (44.23%), and Scientific literature 141 (34.64%) (Table 4). The score for single-test reliability analysis of McDonald's ω was 0.832, Cronbach's α was 0.836, Gutmann's λ_2 0.860, Gutmann's λ_6 was 0.880, and Greater Lower Bound was 0.935 with statistically significant ($p < 0.05$).

Table 4: The resources of Pharmacokinetics Services used by nurses.

	Responses	
Scientific literature	141	34.64%
Peer discussions	53	13.02%
Medical association literature/guidelines/recommendations	248	60.93%
Internet (e.g., Google searches, WebMD, etc.)	261	64.13%
Drug labeling	34	8.35%
Laboratory director/personnel	24	5.90%
S.F.D.A. website	36	8.85%
None of the above have consulted any source	12	2.95%
Drug information resources (Micromedex, Lexicomp, Epocrate, ...)	180	44.23%
Answered	407	
Skipped	1	

Factors Effects the Nurse's basic Knowledge of Pharmacokinetics 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. Nurse's basic knowledge about Pharmacokinetics services includes location, site of work, age (years), nurse gender, and nurse qualification. Nurses' practice area, years of experience, position held, drug levels of pharmacokinetics services at the institution, requisition any drug levels before, number of drug levels requisition, number of patients needed for drug levels services, perception of drug levels services. Three factors only (nurse qualification, position held, the presence of drug levels of pharmacokinetics services at the institution) out of thirteen were statically significant released ($p < 0.05$). The lowest scores (2.5111) were obtained from Ph.D nurse, with statistically significant differences among all sites ($p = 0.000$). Four levels of nursing position affected the nurses' basic knowledge about Pharmacokinetics services, with the highest score (2.9227) obtained for

Table 5: Pharmacokinetics Services assessment of knowledge.

No	Items	Yes		No		Uncertain		I do not know		Total	Weighted Average	p-value (X2)
1	Have you ever heard about Pharmacokinetics (drug levels)?	89.90%	365	8.13%	33	1.97%	8	0.00%	0	406	3.88	0.000
2	Have you ever heard about the concept of therapeutic drug monitoring?	74.45%	303	23.10%	94	1.72%	7	0.74%	3	407	3.71	0.000
3	Have you ever had a course/attended a workshop about Pharmacokinetics services or therapeutic drug monitoring?	42.89%	175	54.66%	223	0.49%	2	1.96%	8	408	3.38	0.000
4	In Saudi Arabia, are there legal provisions in the Medicines Act that provide for Pharmacokinetics activities?	63.93%	257	8.71%	35	4.23%	17	23.13%	93	402	3.13	0.000
5	In Saudi Arabia, is there a Pharmacokinetics service?	65.26%	263	5.71%	23	5.21%	21	23.82%	96	403	3.12	0.000
6	Is there an official standardized form requesting Pharmacokinetics services or drug levels in Saudi Arabia?	64.60%	261	7.18%	29	4.70%	19	23.51%	95	404	3.13	0.000
7	Do you know from where you can get the Pharmacokinetics services or drug level form?	81.03%	329	9.11%	37	2.71%	11	7.14%	29	406	3.64	0.000
8	Do you know what is the time within which you should request drug levels?	83.00%	337	9.85%	40	2.46%	10	4.68%	19	406	3.71	0.000
9	Do you know the estimated drug dosing interval?	76.54%	310	15.56%	63	3.21%	13	4.69%	19	405	3.64	0.000
10	Do you know the estimated medication half-life?	73.40%	298	18.97%	77	4.68%	19	2.96%	12	406	3.63	0.000
11	Do you know the time needed to reach drug level steady-state levels?	71.18%	289	20.69%	84	3.94%	16	4.19%	17	406	3.59	0.000
12	Do you know the dose calculation in renal failure?	64.43%	259	26.87%	108	3.23%	13	5.47%	22	402	3.5	0.000
13	Do you know the dose calculation in hepatic failure?	61.04%	246	28.78%	116	4.71%	19	5.46%	22	403	3.45	0.000
14	Do you know the dose calculation in obese patients?	62.13%	251	30.45%	123	3.47%	14	3.96%	16	404	3.51	0.000
15	Do you know the drug interaction that increases or decreases blood drug levels?	58.23%	237	34.15%	139	4.67%	19	2.95%	12	407	3.48	0.001
16	Do you know the cost of drug-level analysis?	50.62%	204	32.01%	129	3.47%	14	13.90%	56	403	3.19	0.000
	Answered									408		
	Skipped									0		

nursing staff with a statistically significant difference between all levels ($p=0.000$). Drug levels of pharmacokinetics services at the institution with the lowest score (2.5011) affected nurses' basic knowledge about Pharmacokinetics services with a statistically significant difference between all answers ($p=0.000$) (Table 5).

The relationship between the nurses' basic knowledge about Pharmacokinetics services and factors such as Location, Site of work, Age (years), Nurse gender, and nurse qualification. Nurses' practice area, Years of experience, Position Held, Drug levels of pharmacokinetics services at the institution, requiring any drug levels before, Number of drug levels requisition, Number of patients needed for drug levels services, Perception of drug levels services. The multiple regression analysis considered perception as the dependent variable and factors affecting it as an explanatory variable. There was a medium relationship ($R=0.534$ with $p=0.000$) between the nurses' basic knowledge of Pharmacokinetics services and its factors. Three (Nurses' qualification, position held, and the presence of Drug levels of pharmacokinetics services) out of thirteen were significant differences ($p<0.05$). The multiple regression analysis confirmed that two factors, position held and the presence of Drug levels of pharmacokinetics services) explained 18.7% and 24.7%, respectively, of the negative relationship to the variation in knowledge, with a statistically significant difference ($p=0.000$) and ($p=0.000$). At the same time, one factor (Nurse qualification) explained an 11.7% positive relationship to the variation in knowledge, with a statistically significant difference ($p=0.018$). 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 1.231, 1.271, and 1.560, respectively less than three or five as a sufficient number of V.I.F. (Table 5).

DISCUSSION

Pharmacokinetic services can potentially impact the patient clinically or economically.⁵ The nursing staff plays an essential role in the practice of the pharmacokinetics team. The knowledge of Pharmacokinetics is the background of the practice. Assessing nursing knowledge of pharmacokinetic services is critical and required to improve pharmacokinetic services. The cross-sectional study calculated the number of samples better than the previous physician study² and lower than other study,⁹ convenient method of sampling, and high-reliability validation of the survey, which might give an initial global picture of nursing knowledge of pharmacokinetics services in Saudi Arabia resembling previous physician study.² The survey respondents were from various regions; however, most were from the central and southern areas without apparent reason. Most respondents from M.O.H. hospitals related to the survey distributors have easy access to M.O.H. hospitals. The age distribution is statistically significant but not clinically significant in practice. The highest age level was 35-45 years, an excellent sample for an appropriate picture of pharmacokinetic services. The nursing staff with more than four years of experience has the highest number, which is good to reflect the accurate picture of pharmacokinetic services. The nursing practice was good, with statistically significant distribution but not clinically meaningful. Most respondents had drug levels services and

Table 6: Multiple regression of Factors with the nurses's basic knowledge about Pharmacokinetics Services.

Model	R Square	F	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
				B	Std. Error				Beta	t	Lower Bound	Upper Bound
1	.534 ^b	11.064	.000 ^b	4.080	.292		13.974	.000	3.506	4.655		
				-.030	.020	-.073	-1.527	.128	-.068	.009	.855	1.169
				.007	.011	.029	.615	.539	-.015	.029	.878	1.139
				.062	.034	.090	1.820	.070	-.005	.129	.813	1.230
				-.014	.043	-.015	-.324	.746	-.099	.071	.947	1.056
				.165	.069	.117	2.375	.018	.028	.301	.813	1.231
				-.009	.007	-.054	-1.188	.236	-.023	.006	.970	1.031
				.029	.028	.053	1.034	.302	-.026	.084	.741	1.349
				-.119	.032	-.187	-3.717	.000	-.183	-.056	.787	1.271
				-.303	.068	-.247	-4.436	.000	-.438	-.169	.641	1.560
				-.144	.089	-.097	-1.615	.107	-.319	.031	.553	1.808
				-.003	.011	-.015	-.307	.759	-.026	.019	.868	1.152
				.045	.041	.053	1.111	.267	-.035	.125	.871	1.148
				-.157	.087	-.095	-1.805	.072	-.327	.014	.712	1.405

a. Dependent Variable: Nurses' basic knowledge about Pharmacokinetics services, Predictors: (Constant), Location, Site of work, Age (years), Nurse gender, Nurse qualification, Nurses' practice area, Years of experience, Position Held, The presence of Drug levels of pharmacokinetics services at the institution, Requiring any drug levels before, Number of drug levels needed for drug levels services, Perception of drug levels services

Model	Bootstrap for Coefficients					
	B	Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
					Lower	Upper
1	4.080	.025	.296	.001	3.528	4.717
	-.030	.000	.020	.147	-.069	.011
	.007	.000	.010	.498	-.012	.026
	.062	7.712E-05	.037	.093	-.010	.136
	-.014	.002	.043	.741	-.101	.068
	.165	-.005	.052	.001	.058	.263
	-.009	2.274E-05	.007	.217	-.022	.005
	.029	-.001	.035	.434	-.045	.091
	-.119	-.003	.023	.001	-.169	-.076
	-.303	.000	.133	.027	-.559	-.019
	-.144	.000	.148	.298	-.435	.149
	-.003	.001	.012	.781	-.027	.022
	.045	.001	.035	.201	-.028	.111
	-.157	-.001	.144	.259	-.451	.125

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

practiced it before, which had a good view of pharmacokinetics services. The overall scores of nursing knowledge of pharmacokinetics services are appropriate resemble of previous physician study⁹ but need to be revised. Most nursing families have basic concepts of pharmacokinetics services and sampling time of withdrawal blood from the patient. However, some nursing staff needs to include the legal aspects of pharmacokinetics services and local or national standards of pharmacokinetics services, and they miss the education on pharmacokinetics services at healthcare facilities. Most pharmacokinetics references nurses use are from the Internet and medical literature, and sometimes, the appropriate references are used, such as drug information resources. It Further, some elements of knowledge Should reviewed to improve the nursing knowledge of pharmacokinetics services, such as dosing calculation in renal and hepatic disorder, potential drug interactions leading to increased levels, and cost analysis of pharmacokinetics services. It differed from physician study which consult the pharmacist for dosing information calculation.⁹

Only two factors might negatively affect nursing knowledge of Pharmacokinetics, such as position and present drug level at healthcare facilities related to highly favorable not practice pharmacokinetics and present of drug level, which might negatively impact nursing staff, which is not supposed to. Some nurses must be more active with the available drug levels and will not read about well-known services inside healthcare facilities. One other with high qualifications of nursing staff might have positive outcomes by increasing nursing knowledge of pharmacokinetics services, which is expected.

The nursing knowledge of pharmacokinetic services is appropriate, but more is needed. Pharmacokinetic services standardization and regular pre- and post-graduate education are required to improve the pharmacokinetic services in Saudi Arabia.

LIMITATION

Despite the informative research about new knowledge of pharmacokinetics services through appropriate calculated sample size and high reliability validated survey, There are various limitations such as the sampling method used was not randomized techniques, not equal responding distribution of nurse-based geographic areas, and different specialties and practice area lead to changes in nursing knowledge. Further research using a randomized sampling method with an equal sample size and the same demographic characters is optimal.

CONCLUSION

Nursing knowledge of pharmacokinetics services is reached at an acceptable level through a cross-section survey with a calculated sample size. Pharmacokinetics services were available in most healthcare organizations. The pharmacokinetics services had various drawbacks, such as unclear pharmacokinetics standards, and the legal aspect of pharmacokinetics was not understood. The references used for pharmacokinetics knowledge by nursing staff were not appropriate. The nurse had a positive attitude toward nursing knowledge of pharmacokinetics services, while the nursing posting had a negative impact. Targeting of reviewing for pharmacokinetics standees and legality with further research without limitation of sampling techniques is warranted to improve nursing knowledge of pharmacokinetics 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 (I.R.B.) approval.

<https://www.hhs.gov/ohrp/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.

ORCID ID

<https://orcid.org/0000-0003-1381-628X>

REFERENCES

1. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: Prescribing and transcribing-2013. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists. 2014;71(11):924-42. doi: 10.2146/ajhp140032. PubMed PMID: 24830997.
2. Mohamed SI, Yousef Ahmed A, Randa MA-S, Yara AA, Renad AA. Practice of Pharmacokinetics Services by Physicians in Saudi Arabia. Journal of Pharmaceutical Negative Results. 2022;360-72. doi: 10.47750/pnr.2022.13.S07050.
3. Howard CE, Capers CC, Bess DT, Anderson RJ. Pharmacokinetics services in Department of Veterans Affairs medical centers. American journal of hospital pharmacy. 1994;51(13):1672-5. PubMed PMID: 7942892.
4. Cropp CD, Beall J, Buckner E, Wallis F, Barron A. Interprofessional Pharmacokinetics Simulation: Pharmacy and Nursing Students' Perceptions. Pharmacy (Basel). 2018;6(3). doi: 10.3390/pharmacy6030070. PubMed PMID: 30036982; PubMed Central PMCID: PMC6163764.
5. Alomi YA, Aldosary BA, Elshenawy RA. National Survey of Pharmacokinetic Services in Saudi Arabia: Perceptions and Barriers of Service Implementations. International Journal of Pharmacology and Clinical Sciences. 2019;8(3):194-8. doi: 10.5530/ijpcs.2019.8.33.
6. Alomi YA, Elshenawy RA. National Survey of the Pharmacokinetics Services at Ministry of Health Hospitals in Saudi Arabia: Pharmacy Management Practice. International Journal of Pharmacology and Clinical Sciences. 2019;7(4):4-10. doi: 10.5530/ijpcs.2018.7.3.
7. Alomi YA, Elshenawy RA. National Survey of the Pharmacokinetics Services at the Ministry of Health Hospitals in Saudi Arabia: Prescribing and Dispensing Medication. International Journal of Pharmacology and Clinical Sciences. 2019;8(1):11-6. doi: 10.5530/ijpcs.2019.8.3.
8. Alomi YA, Elshenawy RA, Al-Jarallah SM. National Survey of the Pharmacokinetics Services at the Ministry of Health Hospitals in Saudi Arabia: Drug Therapy Monitoring and Healthcare Professional Education. International Journal of Pharmacology and Clinical Sciences. 2019;8(2):99-104. doi: 10.5530/ijpcs.2019.8.17.
9. Alrabiah Z, Alwhaibi A, Alsanea S, Alanazi FK, Abou-Auda HS. A National Survey of Attitudes and Practices of Physicians Relating to Therapeutic Drug Monitoring and Clinical Pharmacokinetic Service: Strategies for Enhancing Patient's Care in Saudi Arabia. Int J Gen Med. 2021;14:1513-24. doi: 10.2147/IJGM.S296731. PubMed PMID: 33935513; PubMed Central PMCID: PMC8079248.
10. Almohammed S, Alhodian H, Almofareh S, Alshehri S, Almasri DM, Ghoneim RH. A survey of therapeutic drug monitoring in a teaching hospital. Saudi J Biol Sci. 2021;28(1):744-7. doi: 10.1016/j.sjbs.2020.11.002. PubMed PMID: 33424362; PubMed Central PMCID: PMC80778382.

11. Sut N, Ajredani M, Kocak Z. Importance of Sample Size Calculation and Power Analysis in Scientific Studies: An Example from the Balkan Medical Journal. *Balkan Med J.* 2022;39(6):384-5. doi: 10.4274/balkanmedj.galenos.2022.31102022. PubMed PMID: 36373703; PubMed Central PMCID: PMC9667214.
12. Pourhoseingholi MA, Vahedi M, Rahimzadeh M. Sample size calculation in medical studies. *Gastroenterol Hepatol Bed Bench.* 2013;6(1):14-7. PubMed PMID: 24834239; PubMed Central PMCID: PMC4017493.
13. Jaykaran, Saxena D, Yadav P, Kantharia ND. Negative studies published in medical journals of India do not give sufficient information regarding power/sample size calculation and confidence interval. *J Postgrad Med.* 2011;57(2):176-7. doi: 10.4103/0022-3859.81861. PubMed PMID: 21654149.
14. Johnson TP, Wislar JS. Response rates and nonresponse errors in surveys. *JAMA : the journal of the American Medical Association.* 2012;307(17):1805-6. doi: 10.1001/jama.2012.3532. PubMed PMID: 22550194.
15. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol.* 2008;61(4):344-9. Epub 2008/03/04. doi: 10.1016/j.jclinepi.2007.11.008. PubMed PMID: 18313558.