Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Biostatistical analysis knowledge of pharmacy research in the Kingdom of Saudi Arabia

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A R T I C L E I N F O

Article history:
Received 7 October 2019
Received in revised form
2 January 2020
Accepted 5 January 2020

Keywords:
Biostatistical analysis
Biostatistics
Pharmacy research
Pharmacy education
Saudi Arabia

A B S T R A C T

The aim of the current study is to explore the Biostatistical analysis of basic knowledge of Pharmacy Research in the Kingdom of Saudi Arabia. It is a 4-months cross-sectional survey of biostatistical knowledge used in pharmacy research. The survey consisted of two-part demographic information and the second part about pharmacist information related to the biostatistical analysis knowledge of pharmaceutical research. The 5-point Likert response scale system used. There were two methods for validation done in the current study; more than two of the authors reviewed the survey independently, the pilot study had been done, then the survey corrects accordingly, and the Cronbach's alpha test for internal reliability. The survey made an electronic format, and it analyzed through Statically Package of Social Sciences (SPSS) version 20, and survey monkey system. The total response was 209 pharmacists. The average score level of knowledge of using all types of statistical analyses in Pharmacy research was (3.23) 64.6 %. The top highest scores of the knowledge of type statistical analysis were Mean (3.73), P-value (3.70), and Standard Deviation (3.67). While the lowest score knowledge of type statistical analysis was Tukey test (2.64), McNemar Test (2.70), and Yates correction for Chi-Square (2.87). The average score level of knowledge of using the software in the statistical analysis in the Pharmacy research was (3.24) 64.8 %. The top highest scores of the experience were Microsoft Excel (3.82), and Microsoft Access (3.29); while the lowest score knowledge was SAS (2.75), and SPSS (3.08). The Cronbach's alpha test results were 0.985. The biostatistical analysis knowledge among pharmacists inadequate in the Saudi Arabia, similar to previous studies. Comprehensive education and training of biostatistics used in pharmacy research are very demandable for pharmacists in Saudi Arabia. Further study with a large scale of the pharmacist, including students, is highly recommended in the Kingdom of Saudi Arabia.

1. Introduction

The pharmacy profession passes through multiple stages in the kingdom of Saudi Arabia. In the early-1960s, the initial phase with the college of pharmacy foundations and graduated the first group of pharmacists worked in the hospitals and healthcare institutions (Asiri, 2011). The main job was storing and dispensing medications to the patients. In the late 1980s, the clinical pharmacy stage. Some graduated clinical pharmacists from overseas with master clinical pharmacy or Pharm D holders. They started clinical activities at some hospitals and full clinical pharmacy practice at other organizations (Alomi et al., 2018a; 2018c; 2018d). In the late 1990s, the pharmaceutical care stage. The concept of pharmaceutical care establishment in the Kingdom of Saudi Arabia (KSA) with some

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https://doi.org/10.21833/ijaas.2020.03.011
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implementation at varies hospital and college of pharmacies started the education of the concept (Asiri, 2011). In the mid-2000s until now, the pharmacy automation stage with electronic prescribing. The Computerized physician order enters at varies hospitals got widening over more hospitals and primary healthcare centers with a cost analysis of the pharmacy services. The pharmacy informatics established and Pharmacoeconomics services widening in practice (Alomi et al., 2018b).

The electronic administration and clinical documentation started to collect massive data through a new computerized pharmacy system. The data analysis involved in the massive data. Those data produced various studies and publications through the current pharmacy research stage. The digital pharmacy data analysis came with new Saudi vision 2030 with an electronic government. The data need preparation of data, analysis of the data, a collaboration between the data, and extrapolate the new data vision in the future. These concepts involved the biostatistics sciences. The new digital pharmacy and mega data, the research and biostatistics analysis are required.

A biostatistical analysis is commonly used in clinical and non-clinical research (Awaisu and Alsalimy, 2015). It defines as "areas of applied mathematics that are required for the proper design and analysis of most experimental or observational data"(Brimacombe, 2014). A complete understanding of clinical research is essential for all pharmacists, including those who are and those who are not actively involved in conducting research. Such skills and knowledge not only equip pharmacists to systematically ask and answer practice-related questions, they better enable them to evaluate clinical researches and medical literature (Streetman et al., 2006). Their ability to interpret biostatistics is very important to critically appraise and summarize any new findings from the medical literature (Bookstaver et al., 2012). Unfortunately, most practicing health professionals have limited understanding and application of biostatistics (Lee et al., 2004; Horton and Switzer, 2005; Wulff et al., 1987; Ferrill et al., 1999; O'Donnell, 2004; Windish et al., 2007).

There is a need to fully explore and identify the barriers and facilitators with a view to increase pharmacists' interest in conducting research and facilitate their involvement. One critical barrier to the integration of evidence-based practice (EBP) is lacking an understanding of research methodology, measurement, and statistical analyses (Cailor et al., 2017). Without such an evaluation, any paper is currently almost incredible. Moreover, the number of medical papers is increasing rapidly, which requires more and more sensitive methods.

Several litterateurs discussed the knowledge or perception of pharmacy and medical research in the KSA or around the world (Awaisu et al., 2015; Awaisu and Alsalimy, 2015; Bhagavathula et al., 2017; Davies et al., 1993). It was seldom finding of study about knowledge or perception of biostatistics analysis (Bookstaver et al., 2012; Schober et al., 2017). To measure the gap between pharmacist knowledge and current practice. The objective of this study is to identify of Biostatistical analysis knowledge of Pharmacy Research in Kingdom of Saudi Arabia

2. Methods

2.1. Study design

It is a 4-months cross-sectional survey of pharmacy research knowledge and biostatistics used in the period of April 15th, 2018, to August 15th, 2018. The survey consisted of two-part demographic information and the second part about pharmacist related information of biostatistical analysis knowledge used in pharmacy research. All non-pharmacist of healthcare professionals excluded in the study. The 5-point Likert response scale system used. The survey distributed through social media by using What's App to more than one thousand healthcare professionals' overall Kingdom of Saudi Arabia. The survey made an electronic format through the survey monkey system.

2.2. Data analysis

A descriptive analysis was performed to describe the data. Mean and the standard deviation was used to describe continuous variables. Frequency and percentage were used to describe categorical variables. Frequency, percentage, and arithmetic means were calculated using Chi-square tests, and data with $p < 0.05$ were considered significant. Missing variables and incomplete answers were calculated. The survey analyzed through Statically Package of Social Sciences (SPSS) version 20, and survey monkey system.

3. Results

The total response was 209 pharmacists. Among the responders, the 185 (88.52%) was Saudi, and 24 (11.48%) was non-Saudi. The gender distribution was male 108 (61.77%) and female 101 (48.33%). The majority of responders 104 (49.67%) were in age (18-29 years) and 78 (37.32%) within age (30-44 years). The most educational level of the responders was a Doctor of Pharmacy 92 (44.32%) and a bachelor's degree in pharmacy 81 (38.94%). Only 16 (8%) has certified pharmaceuticals specialties as explored in Table 1.

The majority of responders are working at Ministry of Health 53 (25.36%) and MOH governmental hospitals 34 (16.27%) followed by Mon-MOH governmental hospitals 30 (14.35%) and private hospitals 30 (14.35%). Most of the responders had <3 experience as pharmacist 86 (42.57%) and >15 years worked as pharmacist 44 (21.78%) with majority of the 77 (40.96%) had staff pharmacist current position with current practice area was outpatient pharmacy 57 (27.67%) and inpatient pharmacy 51 (24.76%) as explored in Table 2.

Table 1: Demographic information of responders

Answer Choices	Responses	
Nationality		
Saudi	88.52%	185
Non-Saudi	11.48%	24
Answered		209
Skipped		0
Sex		
Male	51.67%	108
Female	48.33%	101
Answered		209
Skipped		0
Age (years)		
< 18	0.00%	0
18-29	49.76%	104
30-44	37.32%	78
45-60	11.00%	23
> 60	1.91%	4
Answered		209
Skipped		0
Academic Qualifications		
Diploma pharmacy	4.81%	10
BSc. Pharm	38.94%	81
M.S	8.17%	17
MSc. Clinical Pharmacy	4.33%	9
PharmD	44.23%	92
Ph.D	5.29%	11
MBA	2.88%	6
Pharmacy Residency Two years (PGY1)	2.88%	6
Pharmacy Residency one year (PGY2)	0.48%	1
Fellowship	1.92%	4
Other (please specify)	3.37%	7
Answered		208
Skipped		1
Do you have a Board of Pharmaceutical specialty?		
Board Certified Ambulatory Care Pharmacist (BCACP)	2.00%	4
Board Certified Critical Care Pharmacist (BCCCP)	1.50%	3
Board Certified Nuclear Pharmacist (BCNP)	0.00%	0
Board Certified Nutrition Support Pharmacist (BCNSP)	1.00%	2
Board-certified Oncology Pharmacist (BCOP)	1.00%	2
Board Certified Pediatric Pharmacy Specialist (BCPPS)	0.50%	1
Board Certified Pharmacotherapy Specialists (BCPS)	1.50%	3
Board certified Psychiatric Pharmacist (BCPP)	0.50%	1
Non	91.00%	182
Other (please specify)	4.50%	9
Answered		200
Skipped		9

The average score level of knowledge of using type statistical analysis in the Pharmacy research was (3.23) 64.6%. The top highest scores of the knowledge of type statistical analysis were Mean (3.73), P-value (3.70), and Standard Deviation (Ye et al., 2014) t (3.67). While the lowest score knowledge of type statistical analysis was Tukey s HDS (2.64), McNemar Test (2.70), and Yates correction for Chi-Square (2.87) as explored in Table 3.

The average score level of knowledge of using the software in the statistical analysis in the Pharmacy research was (3.24) 64.8%. The top highest scores of the knowledge were Microsoft Excel (3.82), and Microsoft Access (3.29). While the lowest score knowledge was SAS (2.75), and SPSS (3.08) as explored in Table 4.

Table 2: Demographic information of responder's institutions

Answer Choices	Responses	
Sector of work		
Ministry of Health	25.36%	53
General Medical Directorate in Region	1.91%	4
MOH government Hospital	16.27%	34
Non- MOH government Hospital	14.35%	30
MOH-Primary Care Center	1.44%	3
Private Hospital	14.35%	30
Private Primary Care Center	0.00%	0
Community pharmacy	0.96%	2
University	11.48%	24
Saudi FDA	1.91%	4
Military	2.39%	5
Pharmaceutical company	0.48%	1
Unemployed	3.83%	8
Retired	0.48%	1
Other	4.31%	9
Answered		207
Skipped		2
Total years worked as a Pharmacist		
<3	42.57%	86
3-5	9.90%	20
6-10	15.35%	31
11-15	10.40%	21
> 15	21.78%	44
Answered		202
Skipped		7
Your Current Position		
General Manager of Pharmaceutical care	5.85%	11
Manager of Pharmaceutical care at the region	2.13%	4
Director of Hospital pharmacy	4.26%	8
Supervisor of pharmacy units	12.77%	24
Director of Primary care center pharmacy	0.53%	1
Pharmacy Technicians	4.26%	8
Lecturer	5.85%	11
Staff Pharmacist	40.96%	77
Community Pharmacist	2.13%	4
Clinical Pharmacist	12.23%	23
Pharmacy student	7.98%	15
Deputy Director of Pharmacy	1.06%	2
Answered		188
Skipped		21
The current practice area		
Pharmacy Administration	4.78%	10
Inpatient Pharmacy	24.76%	51
Outpatient Pharmacy	27.67%	57
Satellite Pharmacy	0.00%	0
Narcotics	1.46%	3
Extemporaneous Preparation	0.00%	0
Clinical Pharmacy	10.19%	21
Inventory Control	0.97%	2
Drug Information	3.88%	8
Emergency pharmacy	0.97%	2
Medication safety	1.94%	4
Repacking	0.00%	0
Pharmacy Education and Training	5.83%	12
Pharmacy Research	0.97%	2
Primary care pharmacy	0.97%	2
Community pharmacy	1.94%	4
Other (please specify)	13.40%	28
Answered		206
Skipped		3

Three factors may contribute to the knowledge of biostatistical analysis used in pharmaceutical research. There is no statistically significant between males and females in the complete knowledge of all twenty-six elements of biostatistical analysis used in pharmacy research (p>0.05). Besides, there is no statistically significant between male and female in the complete knowledge of all software used in the biostatistical analysis used in the pharmacy research (p>0.05) except Microsoft access female more dominant than male (p<0.05).

Table 3: The level of knowledge about the type of using biostatistical analysis in the research

		Complete knowledge		Incomplete knowledge		Weak knowledge		I do not have knowledge		I do not need this knowledge		Total	Weighted Average
1	Description analysis	17.31%	36	21.63%	45	24.52%	51	34.62%	72	1.92%	4	208	3.18
2	Mean	42.44%	87	15.61%	32	16.59%	34	22.93%	47	2.44%	5	205	3.73
3	Mode	34.62%	72	16.83%	35	19.71%	41	26.44%	55	2.40%	5	208	3.55
4	Median	38.94%	81	18.27%	38	15.38%	32	24.04%	50	3.37%	7	208	3.65
5	Standard Deviation	39.90%	83	17.79%	37	15.87%	33	22.60%	47	3.85%	8	208	3.67
6	Standard Error of Mean	23.92%	50	26.79%	56	20.10%	42	26.32%	55	2.87%	6	209	3.43
7	The nominal, ordinal, continuous variable	23.19%	48	16.91%	35	21.26%	44	36.23%	75	2.42%	5	207	3.22
8	P value	32.85%	68	27.05%	56	18.84%	39	19.32%	40	1.93%	4	207	3.70
9	Confidence Interval (CI)	27.32%	56	31.71%	65	16.10%	33	24.39%	50	0.49%	1	205	3.61
10	Paired T test	20.10%	42	22.01%	46	21.53%	45	34.45%	72	1.91%	4	209	3.24
11	Unpaired T test	19.81%	41	18.36%	38	25.12%	52	34.78%	72	1.93%	4	207	3.19
12	Chi Square	19.71%	41	19.71%	41	22.12%	46	37.02%	77	1.44%	3	208	3.19
13	One-way ANOVA	22.12%	46	15.87%	33	24.04%	50	36.06%	75	1.92%	4	208	3.2
14	Two-way ANOVA	19.62%	41	17.70%	37	22.01%	46	37.80%	79	2.87%	6	209	3.13
15	Regression analysis	14.90%	31	21.63%	45	24.04%	50	37.02%	77	2.40%	5	208	3.1
16	Z Score	10.68%	22	18.93%	39	22.82%	47	43.69%	90	3.88%	8	206	2.89
17	Correlation Coefficient	24.27%	50	20.39%	42	20.87%	43	32.04%	66	2.43%	5	206	3.32
18	Odds ratios	21.84%	45	30.58%	63	18.93%	39	27.67%	57	0.97%	2	206	3.45
19	Wilcoxon Rank Sum	12.62%	26	19.42%	40	16.99%	35	48.54%	100	2.43%	5	206	2.91
20	Fisher s Exact	13.53%	28	19.81%	41	19.32%	40	43.96%	91	3.38%	7	207	2.96
21	Mann-Whitney	14.98%	31	16.91%	35	21.26%	44	43.00%	89	3.86%	8	207	2.96
22	Kruskal-Wallis ANOVA	12.08%	25	19.32%	40	21.26%	44	43.96%	91	3.38%	7	207	2.93
23	Yates correction for Chi Square	8.70%	18	20.29%	42	23.67%	49	44.44%	92	2.90%	6	207	2.87
24	McNemar Test	7.66%	16	14.83%	31	21.53%	45	52.15%	109	3.83%	8	209	2.70
25	Tukey s HDS	7.18%	15	12.44%	26	20.57%	43	56.94%	119	2.87%	6	209	2.64
26	Type of Error	24.15%	50	32.37%	67	21.26%	44	21.74%	45	0.48%	1	207	3.58
													3.23
												Answered	209
												Skipped	0

There is no statistically significant of all group of ages of used all software used in the biostatistical analysis, and utilization the biostatistical elements in pharmacy research (p>0.05) except only the age (18-29 years) more than age (30-44 years) of complete knowledge of Odds ratios (p<0.05). The pharmacist holds PharmD had statistically significant with complete knowledge of fourteen only biostatistical analysis tools used in the Pharmacy research key elements then BSc. Pharm holders (p<0.05) as explored in Table 5. However, there is no statistically significant type in the academic qualifications of all software used in the biostatistical analysis used in pharmacy research (p>0.05).

Table 4: The level of knowledge using the software in the statistical analysis in the research

	Complete knowledge		Incomplete knowledge		Weak knowledge		I do not have knowledge		I do not need this knowledge		Total	Weighted Average
Microsoft Excel	33.97%	71	29.67%	62	22.01%	46	12.92%	27	1.44%	3	209	3.82
Microsoft Access	17.39%	36	24.64%	51	30.43%	63	24.64%	51	2.90%	6	207	3.29
SPSS	13.04%	27	21.26%	44	27.54%	57	36.71%	76	1.45%	3	207	3.08
SAS	5.77%	12	18.75%	39	22.12%	46	50.96%	106	2.40%	5	208	2.75
Survey Monkey Analysis	19.90%	41	24.27%	50	19.90%	41	33.98%	70	1.94%	4	206	3.26
Average												3.24
											Answered	209
											Skipped	0

4. Discussion

Understanding biostatistics is critical for pharmacists to enable them interpreting the findings of medical studies and providing safe and effective pharmaceutical care. The new era of digital pharmacy established before 15 years in the kingdom of Saudi Arabia (Alomi et al., 2018b). The general administration of pharmaceutical care engaged in this field through established the pharmacy strategic plan and updated plan with the new Saudi vision 2030 (Alomi et al., 2015; Alomi et al., 2018c). The mega raw data needs the great working of biostatistics and data analysis. In the study occurred to explore the knowledge level of biostatistics in pharmacy research. The findings revealed the level of knowledge not adequate. Most respondents reported having poor knowledge in biostatics, and the complete knowledge did not reach 50% in any of statistical concepts. This trend is consistent with other international studies that reported poor knowledge in biostatistics among pharmacists (Bookstaver et al., 2012; Ferrill et al., 1999; Awaisu et al., 2015) and other health care providers (Windish et al., 2007; Schober et al., 2017; Shetty et al., 2015). On the other hand, a study conducted among resident physicians in Jeddah released contradictory results, where participants showed good knowledge in biostatistics and research methods (Al-Zahrani and Al-Khail, 2015). These inconsistent results may be related to the fact that the previous study was carried out among residents whose educational status still active (in a residency program), whereas our participants mostly had graduated years ago and have been involved in the professional market. It is an undeniable fact that earlier graduation is related with losing some of the scientific efficiency including biostatistical proficiency which might be due to lack of motivation, and time required for attending additional training, updating statistical information and achieving research studies (Wulff et al., 1987; Berwick et al., 1981; McColl et al., 1998). Most of the pharmacists had a fundamental knowledge of biostatistics with an emphasis on basic knowledge of descriptive biostatistics while the in-depth information with inferential biostatistics had not accepted the level of knowledge. The necessary information is straightforward to make with little conclusion that came up with it. The advance biostatistics can come to consider recommendations and conclusions currently and for the future.

In the present study, less than 50% of participants reported having comprehensive knowledge in descriptive statistics including measures of central tendency (mean, mode and median) and measures of variability (standard deviation and standard error of the mean). Polychronopoulou et al. (2011) pointed out that some published studies lack descriptive statistics (Polychronopoulou et al., 2011), which confirm the prominence of deficient knowledge about descriptive statistics at the international level. For awareness about the level of measurements, 36.23% of participants admitted that they do not have knowledge about variable categories including categorical (Nominal, ordinal) and continuous (interval and ratio) variables, while those who considered themselves fully knowledgeable in variables were only 23.19%. In 2013, a study in America showed high percentages of pharmacists who have good knowledge of continuous, ordinal, and nominal variables (83.4%, 79.8%, and 72.5% respectively). In reality, descriptive statistics and variables are considered as basics in biostatistics. However, almost more than two-thirds of our participants have inappropriate knowledge of such statistical topics. These disappointing findings reflect a massive gap in the level of statistical knowledge that needs to be filled.

Table 5: The factors (academic qualifications) related the type of using biostatistical analysis in the research

		Factors	Complete knowledge		Incomplete knowledge		Weak knowledge		I do not have knowledge		I do not need this knowledge		Total		Weighted Average	p-value
1	Mean	Bsc. Pharm	30.00%*	24	13.75%	11	20.00%	16	32.50%*	26	3.75%	3	38.28%	80	3.34	<0.05
		PharmD	47.83%*	44	14.13%	13	18.48%	17	17.39%*	16	2.17%	2	44.02%	92	3.88	<0.05
2	Mode	Bsc. Pharm	24.69%*	20	16.05%	13	19.75%	16	37.04%*	30	2.47%	2	38.76%	81	3.23	<0.05
		PharmD	43.01%*	40	15.05%	14	19.35%	18	19.35%*	18	3.23%	3	44.50%	93	3.75	<0.05
3	Median	Bsc. Pharm	24.69%*	20	16.05%	13	19.75%	16	37.04%*	30	2.47%	2	38.76%	81	3.23	<0.05
		PharmD	43.01%*	40	15.05%	14	19.35%	18	19.35%*	18	3.23%	3	44.50%	93	3.75	<0.05
4	Standard Deviation	Bsc. Pharm	28.40%*	23	13.58%	11	18.52%	15	33.33%	27	6.17%	5	38.76%	81	3.25	<0.05
		PharmD	45.16%*	42	19.35%	18	16.13%	15	16.13%	15	3.23%	3	44.50%	93	3.87	<0.05
5	P value	Bsc. Pharm	15.00%*	12	28.75%	23	22.50%	18	31.25%*	25	2.50%	2	38.28%	80	3.23	<0.05
		PharmD	46.24%*	43	23.66%	22	16.13%	15	11.83%*	11	2.15%	2	44.50%	93	4.0	<0.05
6	Confidence Interval (CI)	Bsc. Pharm	12.82%*	10	30.77%	24	17.95%	14	37.18%*	29	1.28%	1	37.32%	78	3.17	<0.05
		PharmD	36.56%*	34	31.18%	29	17.20%	16	15.05%*	14	0.00%	0	44.50%	93	3.89	<0.05
7	Type of Error	Bsc. Pharm	17.50%*	14	26.25%	21	25.00%	20	31.25%*	25	0.00%	0	38.28%	80	3.3	<0.05
		PharmD	32.26%*	30	31.18%	29	19.35%	18	16.13%*	15	1.08%	1	44.50%	93	3.77	<0.05
8	Odds ratios	Bsc. Pharm	11.39%*	9	31.65%	25	17.72%	14	39.24%*	31	0.00%	0	37.80%	79	3.15	<0.05
		PharmD	32.26%*	30	29.03%	27	17.20%	16	19.35%*	18	2.15%	2	44.50%	93	3.7	<0.05
9	Paired T test	Bsc. Pharm	13.58%*	11	19.75%	16	18.52%	15	45.68%*	37	2.47%	2	38.76%	81	2.96	<0.05
		PharmD	25.81%*	24	19.35%	18	29.03%	27	24.73%*	23	1.08%	1	44.50%	93	3.44	<0.05
10	Chi Square	Bsc. Pharm	12.35%*	10	16.05%	13	20.99%	17	48.15%*	39	2.47%	2	38.76%	81	2.88	<0.05
		PharmD	25.81%*	24	18.28%	17	24.73%	23	30.11%*	28	1.08%	1	44.50%	93	3.38	<0.05
11	One way ANOVA	Bsc. Pharm	13.58%*	11	12.35%	10	20.99%	17	50.62%*	41	2.47%	2	38.76%	81	2.84	<0.05
		PharmD	26.88%*	25	15.05%	14	29.03%	27	26.88%*	25	2.15%	2	44.50%	93	3.38	<0.05
12	Two way ANOVA	Bsc. Pharm	11.11%*	9	13.58%	11	19.75%	16	50.62%*	41	4.94%	4	38.76%	81	2.75	<0.05
		PharmD	23.91%*	22	18.48%	17	26.09%	24	29.35%*	27	2.17%	2	44.02%	92	3.33	<0.05
13	Fisher s Exact	Bsc. Pharm	6.25%*	5	17.50%	14	22.50%	18	51.25%	41	2.50%	2	38.28%	80	2.74	<0.05
		PharmD	20.43%*	19	16.13%	15	21.51%	20	38.71%	36	3.23%	3	44.50%	93	3.12	<0.05
14	The nominal, ordinal, continuous variable	Bsc. Pharm	16.25%	13	12.50%	10	21.25%	17	47.50%	38	2.50%	2	38.28%	80	2.93	<0.05
		PharmD	30.11%	28	18.28%	17	21.51%	20	27.96%	26	2.15%	2	44.50%	93	3.46	<0.05

* p<0.05

P-value plays a vital role in making clinical decisions in clinical practice. However, 18.84 % of our participants were found to be having weak knowledge of P-value. The knowledge about p-value is extremely variable from that country to another. For example, an American study reported poor knowledge among pharmacists, where approximately 70% of participants were found to be lacking knowledge about p-value (Ferrill et al., 1999). Another study among medical residents found that 59% of the study sample correctly identified the meaning of P-value (Windish et al., 2007). The variations in credit hours of biostatistics courses, the quantity, and quality of biostatistics curriculum as well as in the educational systems among universities in different countries might be the reasons behind such dissimilarities. In terms of knowledge about inferential statistics (parametric and non-parametric tests), less than a quarter of our respondents showed good knowledge about parametric tests such as paired t-test, unpaired t-test, one-way ANOVA and two-way ANOVA.

In contrast, the knowledge towards non-parametric tests including the Mann-Whitney U test, Wilcoxon Matched Pairs (Wilcoxon signed-rank), Kruskal–Wallis test and Chi-square test was much lower compared with parametric tests. This may be associated with the fact that non-parametric tests are less efficient statistical tests and their use is just a second option in case of failing to meet assumptions of parametric tests which may be a reason behind paying less concern for understanding non-parametric tests. This explanation might be argued by Bookstaver et al. (2012) who revealed that respondents scored higher in identifying the statistical tests used for nominal variables (non-parametric tests). The inadequate knowledge in inferential statistics is somehow justifiable inferential statistics are one of the advanced topics in statistics were understanding them requires having theoretical knowledge in basics of mathematics, types of variables, levels of measurements, assumptions that must be fulfilled for determining the appropriate statistical analysis. This wide range of topics makes parametric and non-parametric tests complex topics, especially for pharmacists who are in reality, not statisticians. Furthermore, practical knowledge of SPSS software for achieving such tests is an extra challenge for understanding inferential analysis.

As an essential part of statistics, knowledge toward statistical errors committed in research studies was also assessed, which include type 1 error (rejection of true H0) and type 2 error (acceptance of false H0) (Banerjee et al., 2009). Over than half of participants declared having insufficient knowledge toward types of statistical errors, while 21.74% clearly stated that they have no idea about types of errors. It is a well-known fact that committing an error in hypothesis testing leads to contradictory findings (Akobeng, 2016). The ignorance about types of statistical errors in inferential statistics is an alarming indicator and necessitate to be taken seriously because it releases some suspicions about the validity of current literature used by clinicians in clinical practice. As a confirmation for our doubts, studies had documented that statistical errors are still seen in the literature (Murphy, 2004; Neville et al., 2006; Schatz et al., 2005). In pharmaceutical research, falsely concluding that two treatments are significantly different (type I error) might leads to recommending new incorrect clinical practice that might threats people life, whereas committing type II error (failing to reject a null hypothesis that is actually false in the population) might delay and/or exclude introducing new advancement that might save people life (Kim, 2015). For these reasons, investigating the quality of published studies is a future research area in KSA.

Software applications and techniques used in data collection and data analysis are also another concern for lacking knowledge among pharmacists. Inadequate knowledge toward software was found among most participants. Our findings are supportive of other international studies. For example, a study conducted in Qatar highlighted the poor knowledge of hospital pharmacists about statistical software. It was indicated that just 6.7% of Qatari pharmacists self-assessed themselves as being extremely competent in dealing with software-based statistical analysis, while 17.5% evaluated themselves as very competent (Awaisu et al., 2015). In addition to that, a study among Nigerian pharmacists proved deficiency in performing statistical analysis utilizing software packages such as SPSS, STATA, and EpiInfo (Abubakar et al., 2018). The most insufficient knowledge in the present study was reported for SAS, followed by SPSS, Microsoft Access, survey monkey, and Microsoft Excel, respectively. The highest knowledge about spreadsheet applications (Microsoft Access and Microsoft Excel) might be attributed to the fact that both are general applications that are integral parts of any computer, they are frequently used for statistical and non-statistical analysis purposes which are expected to be the reason of being familiar concepts by participants. For knowledge about SPSS and SAS, respondents showed higher comprehensive knowledge for SPSS (13.04% VS. 5.77%). These findings are not surprising since the use of SPSS in KSA is more common than using SAS. Furthermore, unlike SAS, Saudi educational institutions teach SPSS as a syllabus in medical fields, including pharmacy. The inadequate knowledge of biostatistics revealed the week's education and training during under and postgraduate studies. Besides, continuous education and training are seldom finding the practice with an emphasis not utilized well in pharmaceutical research.

Several factors may affect the knowledge of biostatistics or analysis software, including gender factor; the findings revealed there is not any difference between both males and females. The age categories still, there is not much difference in the level of knowledge or software utilization except in one thing odd ratio without clear justification. The findings declared the higher academic qualifications had more knowledge of biostatistics similar to the previous study (Ferrill et al., 1999). That is related to changes in the pharmacy school curriculum and switched from bachelor's degree to Doctor Pharmacy professional. By comparing the level of knowledge between PharmD and B. Pharm graduates, there was significantly higher knowledge among pharmacists who have a PharmD degree. Many international studies evaluated the level of pharmacists' knowledge about different health aspects and confirmed that post-bachelorette degrees or training are associated with higher knowledge. Logically, the longer duration of PharmD study, the higher number of credit hours for biostatistics syllabus in the PharmD curriculum, the greater involvement of PharmD degree holders in research and evidence-based medicine make them more knowledgeable in understanding biostatistics. Moreover, unlike graduates from bachelor's degrees, Doctor of Pharmacy graduates usually work in clinical settings where a good environment for gaining knowledge in research and biostatistics since evidence-based medicine is an integral part of their daily clinical activities (Garipelly et al., 2012). Some countries have realized the inferiority of B. Pharm program in comparison with PharmD in terms of scientific efficiency of graduates, and have introduced new strategies to shift practiced pharmacists from B. Pharm to PharmD (Deshpande et al., 2012). We, at this moment, encourage targeting tutorial and training activities in Saudi Arabia for those who graduated from a bachelor of pharmacy to ensure standardized knowledge for all pharmacists.

Based on the presented findings, we recommend encouraging pharmacists to involve in research activities and to learn biostatistics from the early beginning of their academic journey. Having specific knowledge in biostatistics as a requirement for joining pharmacy colleges would be beneficial in forcing prospective pharmacists to be immersed in research and biostatistics. We also recommend evaluating the reliability and validity of the biostatistics curriculum in Saudi universities to find out the possible reasons behind graduating pharmacists with limited knowledge in biostatistics and to ensure graduating pharmacists updated with the latest biostatistical knowledge. Exams of Saudi commissions for health specialists (SCFHS) could help as a barrier for filtering pharmacy graduates who require requalification in biostatistics. Incorporating statistics-related questions would assist in pushing pharmacists to update their knowledge continuously. Training and educational activities in statistics for graduated pharmacists are also paramount. From another perspective, the new rules and regulations sat by SCFHS regarding joining the pharmacy practice residency program should be effective in enhancing the level of pharmacists' knowledge towards biostatistics. Gaining scores from participation in scientific research or publishing in peer-reviewed journals with specific criteria will help to create sufficient skilled researchers and increase research output in KSA. The findings of our study reflect the past situation of knowledge about biostatistics because the new rules for joining the pharmacy residency program have already been applied, for this reason, future studies are required to compare the level of pharmacists' knowledge pre and post implanting those new rules and to determine the extent to which those rules would improve the reported poor knowledge.

The present study certainly played a crucial role in filling the gap in the literature regarding the level of pharmacists' knowledge in KSA about biostatistics; however, it has some limitations that should be addressed; first, poor interest among some pharmacists in participating in the survey could potentially have some effect on the study findings. Secondly, the level of knowledge was assessed based on self-evaluation by participants, and that may be related to self-bias. Misunderstanding questions may have occurred as a result of using an electronic survey. However, every effort had made to clear any ambiguity concerning the questions.

5. Conclusion

The pharmacist showed little knowledge in all biostatistical concepts and software applications used in data collection and analysis. The study proves that there is a high need to find out the possible reasons for such unsatisfying knowledge alongside with implementing strategies to improve the level of pharmacists' knowledge. Reinforcing training for graduated pharmacists with a particular focus on B. Pharm graduates is needed.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions

YA started the research idea. AF and YA have written the paper; AF has supervised the research; YA has analyzed and interpreted the data; AF, AT and AH worked on data collection and prepared the manuscript. Each author listed on the manuscript has seen and approved the submission of the present version of the manuscript and takes full responsibility for the manuscript.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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