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Assessment of Basic and Advanced Knowledge in Biostatistics and Clinical Research among Health care Professionals at King Fahad Medical City, Riyadh, KSA: A cross-Sectional Survey

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Abstract

Background: Adequate biostatistics knowledge among healthcare professionals is imperative for understanding medical literature and practicing evidence-based medicine. This study assessed the basic and advanced knowledge in biostatistics and clinical research among healthcare workers at the King Fahad Medical City (KFMC), Riyadh, Saudi Arabia.

Methods: In this cross-sectional survey, data was collected from healthcare providers using a self-administered questionnaire, having questions related to demographics, biostatistics and clinical research. Data analysis was performed using statistical package SPSS 22.

Results: Of 194 participants (63 [32.5%] consultants, 52 [26.8%] residents, and 79 [40.7%] allied healthcare providers), 45.4% had positive attitude towards learning biostatistics. Only 35.1% correctly answered biostatistics and clinical research instrument-related questions. Half participants had low score, 33% had good score, and 18-19% had excellent score of basic and advanced knowledge of biostatistics and clinical research. The highest degree and number of years of experience in biostatistics after medical school graduation were significantly ($\chi^2_{(2)}$=16.589, p<0.001) associated with basic and advanced biostatistics knowledge scores.

Conclusion: Timely and painstaking training courses in biostatistics and clinical research are needed to improve the research standards in Saudi Arabia. Interested candidates should collaborated with statisticians to improve quality of their work and enhance their statistical skills.

Keywords: Biostatistics; Clinical research; Evidence-based medicine (EBM); Epidemiology; Physicians

Introduction

Biostatistics is recognized as a powerful tool to interpret scientific results [1]. There has been an increased use of statistical methods in recent decades, as documented in a wide range of medical journals [2-4]. It has been estimated that the use of statistical methods per article published in the journal Annals of Rehabilitation Medicine raised from 1.9 in the year 2005 to 2.6 in 2015 [3]. Further, in the same duration, these numbers increased from 2.7 to 3.1 for the papers published in the journal Archives of Physical Medicine and Rehabilitation [3]. Therefore, it is essential for medical researchers to understand biostatistics.

A proper understanding of biostatistics and clinical research among physicians is also important for evidence-based medicine (EBM) practice, for designing medical research, to interpret, and report results obtained from these studies [4]. However, physicians find biostatistics complicated and they encounter difficulties in understanding and interpreting results [5]. Thus, there is a raised risk of poor reporting, methodological errors, misinterpretation of the statistical results, and selective conclusion [6,7].

Previously conducted surveys report that many clinicians have poor skills to analyse the study outcomes and have a low level of understanding in the statistical inference, especially the ones who lack basic knowledge of epidemiology and biostatistics [8-12]. This leads to erroneous reporting of research results. This is even evident from the broad consensus in the scientific community that the standard of statistics used for analysing various data is low and a large portion of the published medical research contains statistical errors and shortcomings [13-21]. Thus, incorrect conclusions could be drawn. Further, research results may be invalid, which altogether may result in a lack of reliability and validity of the scientific studies along with wastage of valuable resources [22].

The understanding of basic statistics and epidemiological methods among physicians working at university hospitals or academic research institutions is expected to be higher than that among general practitioners due to a higher level of exposure to the clinical research environment [23]. Thus, this study was undertaken to assess the basic and advanced biostatistics knowledge among consultants, residents, and allied healthcare professionals at King Fahad Medical City (KFMC).

Material and Methods

Study design

This cross-sectional survey was conducted at KFMC, a tertiary care hospital in Riyadh, Saudi Arabia, from September 2016 to February 2017 after obtaining ethical approval from the Institutional Review

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Board. The survey was conducted in accordance with the code of ethics of the world medical association (Declaration of Helsinki).

Study population

Healthcare workers from different departments at KFMC were selected for the study as per the simple random sampling technique by using random number generation method. Study participants were classified into three broad categories, namely, consultants, residents, and allied healthcare (including physical therapist, medical technologist, clinical nurse, nurse educator, etc.).

Sample size and sampling technique

The sample size was calculated by the Raosoft® sample size software considering an approximate number of consultants, residents, and allied healthcare to be 3000. Presumed prevalence of 50% was tested at 95% confidence interval (CI), 8% margin of error, and 80% power to detect such difference. An estimated sample of 150 participants inflated by a non-response rate of 20%. An estimated sample of 150 participants inflated by non–response rate of 20% which accumulates to 194 participants selected for the study.

Data collection

A self-administered questionnaire was designed, based on the information obtained from the literature (Assessment Resource Tools for Improving Statistical Thinking (ARTIST). Available at https://ore.gen.umn.edu/artist/index.html; last accessed on 09.01.2007). The questionnaire was divided into three sections: first section comprised demographic characteristics and job-related questions, current training level, and experience in biostatistics and EBM; the second section was also adopted from ARTIST website, which is a resource for teaching statistics literacy, reasoning, and thinking (Biostatistics 140.622 Statistical Methods in Public Health II, Department of Biostatistics; Johns Hopkins Bloomberg School of Public Health. Available at http://www.biostat.jhsph.edu/courses/bio622/index.html; last accessed on 07.03.2019). A 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) was used to assess the participants' attitude towards biostatistics and clinical research. A validated questionnaire from the course materials used in statistical studies at the Johns Hopkins Bloomberg School of Public Health (Biostatistics 140.622 Statistical Methods in Public Health II, Department of Biostatistics; Johns Hopkins Bloomberg School of Public Health. Available at http://www.biostat.jhsph.edu/courses/bio622/index.html; last accessed on 07.03.2019) was used for the last section wherein questions related to the biostatistics and clinical research (statistical techniques, study design, and interpretation of study result) were asked. The final version of the questionnaire was validated by administering it to the first 30 participants and modifying it according to the feedback received. The overall Cronbach alpha (α) score was 0.89 in order to validate the questionnaire. This questionnaire was used for data collection from study participants. The percentage and level of scores obtained were classified as low score (<30%), good score (31-60%), and excellent score (>60).

Statistical analysis

All the data obtained were entered and analysed through statistical package SPSS 22 (SPSS Inc., Chicago, IL, USA). Categorical variables such as gender, nationality, age, designation, and other variables were presented in frequencies and percentages. Cronbach α test was applied to assess the internal consistency of knowledge, attitude, and biostatistics related questions. Bivariate analysis, i.e., Pearson's Chi-square was performed to find out the significance of the association between the level of test score and study characteristics. A two-tailed probability value ($\chi^2_{(df)}$, p) <0.05 was considered as statistically significant.

Results

Demographic characteristics

The study included 194 healthcare workers (63 [32.5%] consultants; 52 [26.8%] residents; 79 [40.7%] allied healthcare) from the different departments at KFMC. Of all participants, 120 (61.9%) were females, 61 (31.4%) were Saudi nationals and 133 (68.6%) were Non-Saudi nationals (from 48 nationalities working in the KFMC). Majority of participants i.e., 93 (47.9%) belonged to age group of 31 to 40 years followed by 61 (31.4%) participants in the age group of 21-30 years. Doctor of medicine (MD) was the highest level of qualification (n=70; 36.1%). Of all the participants, 83 (45.1%) had professional experience of 4-10 years. Among all the participants, 88 (45.4%) received their training in medicine. All the demographic characteristics of participants are depicted in Table 1.

Knowledge score of the participants

A total of 63 (32.5%) participants had a good score in basic knowledge of biostatistics and clinical research while 64 (33.0%)

Characteristics	Description	n (%)
Gender	Male	74 (38.1)
	Female	120 (61.9)
Nationality	Saudi	61 (31.4)
	Non-Saudi (from 48 nationalities working in KFMC)	133 (68.6)
Age (years)	20-30	61 (31.4)
	31-40	93 (47.9)
	41-50	36 (18.6)
	>50	4 (2.1)
Designation	Consultant	63 (32.5)
	Resident	52 (26.8)
	Allied healthcare	79 (40.7)
Highest Degree	MD	70 (36.1)
	DO	13 (6.7)
	PhD	26 (13.4)
	MPH/MHS/M.Sc.	21 (10.8)
	Other	64 (33.0)
Years of experience after graduation	<1	7 (3.8)
	1-3	23 (12.5)
	4-10	83 (45.1)
	11-20	61 (33.2)
	> 21	10 (5.4)
Training type	Undergraduate	14 (31.8)
	Residency	20 (45.5)
	Postgraduate	10 (22.7)
Current level of training	Intern	13 (6.7)
	Resident	124 (63.9)
	Post-graduate and above	57 (29.4)
Training Program achieved from	Medicine	88 (45.4)
	Surgery	57 (29.4)
	Pediatrics	29 (14.9)
	Obstetrics and Gynecology	20 (10.3)

MD: Doctor of Medicine; DO: Doctor of Osteopathic Medicine; PhD: Doctor of Philosophy; KFMC: King Fahad Medical City; MPH: Master of Public Health; MHS: Master of Health Science; M.Sc: Master of Science; n: Number of patients

Table 1: Socio-demographic characteristics of the participants.

participants had a good score in advanced knowledge of biostatistics and clinical research. Nearly, 50% of participants had a low score, 33% had good score and 18-19% had an excellent score of cumulative knowledge of biostatistics (basic and advanced) and clinical research (Table 2).

Training in biostatistics, clinical research, and other training/ workshops

In regard to training programs, biostatistics workshop/training was attended by 122 (62.9%) participants while clinical research and epidemiology workshop/training was attended by 124 (63.9%) participants. Similarly, statistical package workshop/training was attended by 101 (52.1%) participants and EBM training was attended by 133 (68.6%) participants. In contrast, R workshop was attended by only one (1.0%) participant (Table 2).

Attitude of participants towards biostatistics learning

Of all the study participants, 114 (58.8%) participants were ready to learn biostatistics if they get a chance to do so. Only 58 (29.9%) participants could understand the statistical terminologies that they come across while reading journal articles. However, 45 (23.2%) participants felt that it is easy to make false statistical reports, therefore they had no trust in them. The detailed results obtained on the assessment of participants' attitude towards biostatistics learning are tabulated in Table 3. Overall, 45.4% of all the participants had a positive attitude towards biostatistics learning (Table 3).

Answers to biostatistics and clinical research knowledge

The test instrument of biostatistics and clinical research comprised of 12 multiple choice questions which focused on the classification of data, description of metric data into average value and dispersion, and non-metric data into rates, and percentages. The distribution of correct answers to questions in this questionnaire is depicted in Table 4. The tools to calculate confidence limits were correctly answered by 66 (34.0%) participants and the range of Pearson's correlation coefficient was correctly answered by 69 (35.6%) participants.

Knowledge Test Score of the Participants		
Characteristics	**Description**	**n (%)**
Basic knowledge score of biostatistics and clinical research	≤30 (Low Score)	94 (48.5)
	31 - 60 (Good Score)	63 (32.5)
	>60 (Excellent Score)	37 (19.1)
Advanced knowledge score of biostatistics and clinical research	≤30 (Low Score)	95 (49.0)
	31 - 60 (Good Score)	64 (33.0)
	>60 (Excellent Score)	35 (18.0)
Past Experience of Biostatistics, Clinical Research, and Other Training/Workshops		
Ever taken a workshop/training in Biostatistics		122 (62.9)
Workshop/training in Biostatistics Institution	Undergraduate school	47 (38.5)
	Training and academic institutions	75 (61.5)
Ever taken a workshop/training in Clinical Research and Epidemiology		124 (63.9)
Workshop/training in Clinical Research and Epidemiology Institution	Undergraduate school	49 (39.5)
	Training and academic institutions	75 (60.5)
Ever taken a workshop/training of Statistical Package		101 (52.1)
Workshop/training of Statistical Package Institution	SAS	26 (25.7)
	SPSS	41 (40.6)
	Stata	16 (15.8)
	Statistica	17 (16.8)
	R	1 (1.0)
Ever had training in EBM		133 (68.6)
Training Institution for EBM	Undergraduate school	68 (52.3)
	Training and academic institutions	62 (47.7)
EBM: Evidence based medicine; n: Number of patients; SAS: Statistical Analysis System; SPSS: Statistical Package for the Social Sciences; R: programming language		

Table 2: Knowledge test score of the participants and their past experience in biostatistics, clinical research, and other training/workshops.

Items	**n (%)**	
	Positive Attitude	**Negative Attitude**
Given the chance, I would like to learn more about biostatistics	114 (58.8)	80 (41.2)
I can understand almost all of the statistical terms that I encounter in journal articles	58 (29.9)	136 (70.1)
Because it is easy to make falsely report in statistics, I don't trust them at all.	45 (23.2)	149 (76.8)
I do not need any assistant with Biostatistician/Data Analyst regarding my research data (I'm enough capable)	31 (16.0)	163 (84.0)
I often use statistical information in forming opinion or making decisions in medical care.	82 (42.3)	112 (57.7)
To be an intelligent reader of the literature it is essential to know something about Statistics	127 (65.5)	67 (34.5)
Trainings and interactive courses of Biostatistics and Statistical Packages are useful for Physicians/ Researcher/Academician?	119 (61.3)	75 (38.7)
Biostatistics is necessary for GCP and EBM	128 (66.0)	66 (34.0)
Overall response rate of attitude towards biostatistics learning	45.4%	54.6%
EBM: Evidence based medicine; GCP: Good Clinical Practice		

Table 3: Positive and negative attitude of participants towards biostatistics learning.

Question Numbers	Questions	n (%)
1a	Birth weight in grams (continuous variable)	60 (30.9)
1b	Birth weight (categorical variable)	104 (53.6)
1c	Type of delivery (nominal variable)	76 (39.2)
2	Identification of measure of dispersion	72 (37.1)
3	Parameter of normal distribution	87 (44.8)
4	Identification of most appropriate graph	56 (28.9)
5	The best measurement of central tendency	65 (33.5)
6	Confidence limits are calculated by using	66 (34.0)
7	The 95% confidence interval mean cholesterol level	64 (33.0)
8	With help of cross-sectional studies, we can calculate	66 (34.0)
9	Identification of case control study design	76 (39.2)
10	Identification of case report	65 (33.5)
11	Relative risk of developing food poison	41 (21.1)
12	The range of Pearson's Correlation Coefficient	69 (35.6)
n: Number of patients		

Table 4: Distribution of correct answers for biostatistics and clinical research knowledge test instruments.

Assessment of basic biostatistics knowledge

Assessment of basic biostatistics knowledge revealed low scores (≤30) in 64 (68.1%) of females and 30 (31.9%) males ($\chi^2_{(2)}$=4.334, p=0.114). Age wise, 41 (43.6%) participants in age range 31-40 scored low ($\chi^2_{(2)}$=2.674, p=0.613). Twenty-seven (n=27; 28.7%) Saudi nationals and 67 (71.3%) Non-Saudi nationals scored low ($\chi^2_{(2)}$=2.954, p=0.228).

Regarding designation and levels of score, 24 (25.5%) consultants had a low score (≤30), 22 (34.9%) consultants had a good score (31-60) and 17 (45.9%) consultants had an excellent score (>60; $\chi^2_{(2)}$=5.300, p=0.021). Among allied healthcare workers, 50 (53.2%) participants had a low score (≤30), 22 (34.9%) participants had a good score (31-60) and 7 (18.9%) participants had an excellent score (>60; $\chi^2_{(2)}$=14.220, p<0.001).

Based on the highest qualification of participants, 25 (26.6%) professionals with MD scored low (≤30) while 26 (41.3%) MD professionals scored good (31-60) and only 19 (51.4%) MD professionals scored excellent (>60; $\chi^2_{(2)}$=8.143, p=0.004). Based on the experience of participants, 47 (52.8%) participants who had 4-10 years of experience after graduation scored low ($\chi^2_{(2)}$=5.138, p=0.023). However, none of the professionals with >21 years of experience scored low ($\chi^2_{(2)}$=16.308, p<0.001). Further, 55 (58.5%) professionals who underwent prior training in biostatistics and 39 (41.5%) professionals who did not undergo prior biostatistics training scored low ($\chi^2_{(2)}$=6.486, p=0.039) (Table 5).

Assessment of advanced biostatistics knowledge

The assessment of advanced biostatistics knowledge revealed low scores (≤30) in 74 (77.9%) females and 21 (22.1%) males. Further, the gender-wise differences in score were found to be statistically significant ($\chi^2_{(2)}$=25.485, p<0.001). A total of 33 (34.7%) participants in age range of 31-40 had low scores ($\chi^2_{(2)}$=17.059, p=0.005). Moreover, 28 (29.5%) Saudi nationals and 67 (70.5%) Non-Saudi nationals scored low; however, the differences between scores based on nationality were not statistically significant ($\chi^2_{(2)}$=0.358, p=0.836).

The level of scores among consultants reached statistical significance ($\chi^2_{(2)}$=11.129, p=0.001) with 21 (22.1%) having low score (≤30), 24 (37.5%) with good score (31-60) and 18 (51.4%) with excellent scores (>60). Among allied healthcare workers, 53 (55.8%) participants had low score (≤30), 22 (34.4%) participants had good score (31-60) and 4 (11.4%) participants had excellent score (>60; $\chi^2_{(2)}$=24.845, p<0.001).

Based on qualification of participants, 19 (20.0%) professionals with MD scored low (≤30), while 30 (46.9%) and 21 (60.0%) professionals scored good (31-60) and excellent (>60), respectively ($\chi^2_{(2)}$=22.568, p<0.001). Based on the experience of participants, 18 (20.2%) participants who had 1-3 years of experience after graduation scored low (≤30), 2 (3.1%) participants with same experience scored good (31-60) and 3 (9.7%) participants scored excellent (>60; $\chi^2_{(2)}$=9.601, p=0.043). Further, 54 (56.8%) professionals who underwent prior training in biostatistics and 41 (43.2%) professionals who did not undergo prior biostatistics training scored low ($\chi^2_{(2)}$=7.772, p=0.023). Similar number of participants in terms of training in research and epidemiology scored low ($\chi^2_{(2)}$=6.068, p=0.048). In regards to EBM training, 58 (61.1%) professionals who underwent prior training in EBM while, 37 (38.9%) professionals who did not undergo prior EBM training scored low ($\chi^2_{(2)}$=13.485, p=0.001) (Table 6).

Discussion

There is a low level of understanding about biostatistics and poor skills to analyse the study outcomes among the clinicians [11,12]. Previous studies conducted on physicians practicing in government or private hospital-based practitioners suggested that they are not fully competent in basic research methodology [24]. In view of abovementioned facts, this study was conducted to assess the basic and advanced biostatistics knowledge among healthcare professionals at KFMC to understand the current requirement of biostatics training for healthcare professionals.

Training of physicians on biostatistics is essential so that they can critically appraise the research question, study design, mode of research conduct, and biostatistical analysis of each study for correct interpretation of results [25]. However, a study by Gezmu et al. [26] highlights that universities in Sub-Saharan Africa do not emphasize on training in biostatistics, due to which there are limited resources with poor interest/knowledge in biostatistics [26]. Overall low scores in the knowledge of biostatistics and clinical research obtained in the study clearly indicate insufficiency of training on statistical software and clinical research methodologies among the practitioners. Although a majority of the participants mentioned that they attended biostatistics and clinical research courses during their medical school tenure as a part of the community medicine; however, they did not emphasize on these courses during their educational tenure.

Gezmu et al. [26] also highlighted that as the researchers are not

Basic Biostatistics Knowledge Score						
Characteristics	Description	Scores [n (n%)]			$\chi^2_{(2)}$	*p*
		≤30 (Low)	31-60 (Good)	>60 (Excellent)		
Gender	Male	30 (31.9)	25 (39.7)	19 (51.4)	4.334	0.114
	Female	64 (68.1)	38 (60.3)	18 (48.6)		
Age (years)	20-30	33 (35.1)	18 (28.6)	10 (27.0)	1.161	0.884
	31-40	41 (43.6)	30 (47.6)	22 (59.5)	2.674	0.613
	41-50	20 (21.3)	11 (17.5)	5 (13.5)	1.133	0.889
	>50	0 (0.0)	4 (6.3)	0 (0.0)	1.042	0.075
Nationality	Saudi	27 (28.7)	18 (28.6)	16 (43.2)	2.954	0.228
	Non-Saudi*	67 (71.3)	45 (71.4)	21 (56.8)		
Designation	Consultant	24 (25.5)	22 (34.9)	17 (45.9)	5.300	0.021
	Resident	20 (21.3)	19 (30.2)	13 (35.1)	3.134	0.076
	Allied healthcare	50 (53.2)	22 (34.9)	7 (18.9)	14.220	<0.001
Highest Degree	MD	25 (26.6)	26 (41.3)	19 (51.4)	8.143	0.004
	DO	9 (9.6)	4 (6.3)	0 (0.0)	3.911	0.047
	PhD	10 (10.6)	10 (15.9)	6 (16.2)	1.203	0.272
	MPH/MHS/M.Sc.	6 (6.4)	8 (12.7)	7 (18.9)	4.662	0.030
	Other	44 (46.8)	15 (23.8)	5 (13.5)	16.870	<0.001
Years of experience after graduation	<1	4 (4.5)	1 (1.7)	2 (5.6)	1.197	0.274
	1-3	11 (12.4)	8 (13.6)	4 (11.1)	0.084	0.772
	4-10	47 (52.8)	20 (33.9)	16 (44.4)	5.138	0.023
	11-20	27 (30.3)	21 (35.6)	13 (36.1)	0.661	0.416
	> 21	0 (0.0)	9 (15.3)	1 (2.8)	16.308	<0.001
Training in Biostatistics	Yes	55 (58.5)	37 (58.7)	30 (81.1)	6.486	0.039
	No	39 (41.5)	26 (41.3)	7 (18.9)		
Training in Research and Epidemiology	Yes	62 (66.0)	35 (55.6)	27 (73.0)	3.395	0.183
	No	32 (34.0)	28 (44.4)	10 (27.0)		
Training of Statistical Package	Yes	52 (55.3)	31 (49.2)	18 (48.6)	0.183	0.678
	No	42 (44.7)	32 (50.8)	19 (51.4)		
Training in EBM	Yes	64 (68.1)	42 (66.7)	27 (73.0)	0.449	0.799
	No	30 (31.9)	21 (33.3)	10 (27.0)		

EBM: Evidence based medicine; MD: Doctor of Medicine; DO: Doctor of Osteopathic Medicine; KFMC: King Fahad Medical City; PhD: Doctor of Philosophy; MPH: Master of Public Health; MHS: Master of Health Science; M.Sc: Master of Science; *p*: Probability value; *: from 48 nationalities working in KFMC

Table 5: Comparative analysis of basic biostatistics knowledge score among study characteristics.

linked with training on biostatistics and they are, thus, unaware of the importance of biostatistics [26]. Moreover, a study conducted in Jeddah City assessing the satisfaction of 80 family physicians during their training program also reported that biostatistics is one of the least important areas of competence in the community medicine course. The study also reported that the study group was moderately trained on biostatistics [27]. Another study by Javali and Sunkad [28] showed that many physicians lacked clear knowledge about statistics and usually had a negative attitude towards its application in their regular practice [28]. Further, most of the participants in the study by Rashid and Subramaniam [24] were negative about attending any additional short courses on biostatistics, as they found statistics to be very difficult and considered training to be time-consuming [24]. In concordance, the study reported that 54.64% of participants had a negative attitude towards biostatics learning.

Several medical schools, nowadays, provide formal teaching and training courses on basic statistical concepts and their use in the medical literature [12,29]. These educational activities aim to train physicians with skills to apply their knowledge about study design and statistical methods for effective evaluation of clinical studies [12]. In this study, despite having biostatistics training and research background, the majority of study participants wrongly answered to the questions about biostatistics and clinical research. The findings of the study are in line with a recent study on healthcare professionals in India [28]. A cross-sectional survey on 531 clinicians from eight countries (including both European and American countries) also reported that the presentation of results in terms of standardized mean difference was poorly understood by the participants [30]. Moreover, it was also perceived to be the least useful. The study also suggested that there is a need to consider various methods to help clinicians in understanding and interpreting results of a research paper [5,30].

In contrast, numerous studies also report adequate knowledge of healthcare professionals in biostatistics. A study by Al-Zahrani and Al-Khail [11], involving 162 resident physicians revealed good knowledge about statistics in more than half of the participants. Further, they had enough knowledge to analyse and interpret research findings [11]. Moreover, resident physicians who underwent prior training in EBM demonstrated better knowledge [11]. Similarly, a study by Baghi and Kornides, 2013 on 165 healthcare professionals (nurses and nurse practitioners) in northern Virginia, United States, revealed a positive attitude toward statistics among study participants even at the beginning of training in biostatistics. This was improved further along with better statistical proficiency after 10 weeks of training [31]. In a study involving 127 healthcare professionals (dental graduates) from 10 European countries, only 37.7% participants correctly answered the questions assessing knowledge corresponding to interpretation of $\chi^2_{(df)}$, *p* value [32]. Interestingly, the knowledge scores in the study were influenced by previous biostatistics/epidemiology training undertaken

Advanced Biostatistics Knowledge Score						
Characteristics	Description	Scores [n (n%)]			$\chi^2_{(2)}$	*p*
		≤30 (Low)	31-60 (Good)	> 60 (Excellent)		
Gender	Male	21 (22.1)	29 (45.3)	24 (68.6)	25.485	< 0.001
	Female	74 (77.9)	35 (54.7)	11 (31.4)		
Age (years)	20-30	38 (40.0)	18 (28.1)	5 (14.3)	8.333	0.054
	31-40	33 (34.7)	34 (53.1)	26 (74.3)	17.059	0.005
	41-50	24 (25.3)	9 (14.1)	3 (8.6)	5.992	0.167
	>50	0 (0.0)	3 (4.7)	1 (2.9)	4.295	0.363
Nationality	Saudi	28 (29.5)	21 (32.8)	12 (34.3)	0.358	0.836
	Non-Saud*	67 (70.5)	43 (67.2)	23 (65.7)		
Designation	Consultant	21 (22.1)	24 (37.5)	18 (51.4)	11.129	0.001
	Resident	21 (22.1)	18 (28.1)	13 (37.1)	3.033	0.124
	Allied healthcare	53 (55.8)	22 (34.4)	4 (11.4)	24.845	<0.001
Highest Degree	MD	19 (20.0)	30 (46.9)	21 (60.0)	22.568	<0.001
	DO	9 (9.5)	4 (6.3)	0 (0.0)	3.703	0.418
	PhD	15 (15.8)	6 (9.4)	5 (14.3)	1.384	0.246
	MPH/MHS/MSc.	7 (7.4)	11 (17.2)	3 (8.6)	4.044	0.853
	Other	45 (47.4)	13 (20.3)	6 (17.1)	17.513	0.001
Years of experience after graduation	<1	2 (2.2)	4 (6.3)	1 (3.2)	1.958	0.728
	1-3	18 (20.2)	2 (3.1)	3 (9.7)	9.601	0.043
	4-10	42 (47.2)	29 (45.3)	12 (38.7)	1.279	0.730
	11-20	26 (29.2)	22 (34.4)	13 (41.9)	1.514	0.876
	> 21	1 (1.1)	7 (10.9)	2 (6.5)	7.670	0.099
Training in Biostatistics	Yes	54 (56.8)	39 (60.9)	29 (82.9)	7.772	0.023
	No	41 (43.2)	25 (39.1)	6 (17.1)		
Training in Research and Epidemiology	Yes	54 (56.8)	42 (65.6)	28 (80.0)	6.068	0.048
	No	41 (43.2)	22 (34.4)	7 (20.0)		
Training of Statistical Package	Yes	47 (49.5)	31 (48.4)	23 (65.7)	3.206	0.201
	No	48 (50.5)	33 (51.6)	12 (34.3)		
Training in EBM	Yes	58 (61.1)	42 (65.6)	33 (94.3)	13.485	0.001
	No	37 (38.9)	22 (34.4)	2 (5.7)		

EBM: Evidence based medicine; MD: Doctor of Medicine; DO: Doctor of Osteopathic Medicine; KFMC: King Fahad Medical City; PhD: Doctor of Philosophy; MPH: Master of Public Health; MHS: Master of Health Science; M.Sc: Master of Science; *p*: Probability value; *: from 48 nationalities working in KFMC.

Table 6: Comparative analysis of advanced biostatistics knowledge score among study characteristics.

by participants. The knowledge scores were significantly higher in participants who underwent previous training that those who did not (51.9 vs. 39.5%, $p<0.001$). Another study involving 219 physicians from Israel demonstrated a high level of knowledge about biostatistics and research methodology. Furthermore, biostatics knowledge significantly correlated with the habit of reading papers and publishing research articles on a regular basis. This indicates that continuous professional education in research is necessary for all healthcare workers in order to remain updated. It also ensures high quality indexed publications in the long run [33].

As per the family physicians included in the study by AlShareef [27] EBM was the most important subject in the family medicine course [27]. Despite knowing the importance of statistical analysis in EBM, physicians mostly find the subject very difficult in comparison to other biomedical subjects [28,34]. To resolve, physicians with good knowledge of literature search and statistical interpretation of medical evidence should take an initiative to create evidence-based guidelines. This can be done by summarizing various medical cases and follow-ups so that there can be a well-documented pool of instructions for EBM practice. Ironically, the resources required to create and maintain guidelines are limited [25,35]. Due to inappropriate and scarcity of resources, physicians need to access original researches and other medical literature to find answers to their clinical questions that may arise during their clinical practice. Therefore, they need to have skills to critically appraise the research question, study design, mode of research conduct, and biostatistical analysis of each study to correctly interpret the results [36].

In the study, a little less than half (48.5%) participants scored low in the overall knowledge score of biostatistics and clinical research and a similar percentage of participants (49%) scored low when were assessed for their advanced knowledge in biostatics. Likewise, a study on pharmacy residents of American Society of Health-System Pharmacists-accredited residency programs demonstrated a lack of biostatistics understanding with a poor overall mean of biostatistics knowledge score of 47.3% in 166 participants, which is comparable to the findings of the study [37]. Lack of knowledge in biostatistics among doctors was also reported by a cross-sectional study in Penang, Malaysia where, of 318 participants, very few participants used basic statistical measures [24]. The study also reported that less than half of the participants read journals regularly and this was attributed to lack of their confidence in the interpretation of results [24]. Further, only one-third of participants were involved in research which was ascribed to inadequate biostatistics training during graduation [24]. Furthermore, a recent cross-sectional study involving medical students in Saudi Arabia showed that there was a significant difference in the mean scores obtained by participants before and after undergoing the biostatistics course. The study also highlighted the requirement of integrating more courses pertaining to biostatics in the medical curriculum for its better understanding and application [12].

Okoro [38], in their questionnaire-based study at the University of Port Harcourt Teaching Hospital, reported poor and inadequate knowledge and biostatistics use among resident doctors [38]. Likewise, this study also revealed low scores in basic biostatistics knowledge test among consultants (25.5% with low score out of 63), residents (21.3% with low score out of 52) and allied healthcare professionals (53.2% with low score out of 79). Moreover, 26.6% of 70 professionals having qualifications as high as MD and 10.6% of 26 professionals with Doctor of Philosophy (Ph.D) scored low in basic knowledge test. The healthcare workers who underwent prior biostatistics/EBM training ([58.5% of 122]; [68.1% of 133], respectively) had also scored low in basic biostatistics knowledge test. Similarly, low scores in advanced biostatistics knowledge test were seen among 22.1% of consultants, 22.1% of residents and 55.8% of allied healthcare professionals. Professionals with MD degree (20.0%) and Ph.D (15.8%) also scored low in advanced knowledge test. Even workers with prior biostatistics/ EBM training (54 [56.8%]; 58 [61.1%] respectively) had low scores in advance biostatistics knowledge test. This highlights the knowledge gap among clinicians and researchers. Further, it also depicts the inadequacy of current biostatistics training and there is a need for better and more intensive biostatistics and clinical research training. As many clinicians/healthcare professionals have little time to develop their statistical knowledge therefore, effort should be made to collaborate with statisticians. A team-based approach towards research, utilizing the knowledge and skills of a statistician, is more productive than clinicians attending statistics education courses alone.

The conduct of the study in a single centre was one of its limitations as is was not entirely a representative of all the hospitals in the Kingdom of Saudi Arabia. Unfortunately, authors could not include questions on advanced methodology in the survey such as Kaplan-Meir analysis, logistic regression, and multivariate modeling. However, the results of the study clearly emphasize the need for promoting research culture among medical professionals and optimizing strategies for the research educational courses and research outreach activities.

Conclusion

The study findings suggest that there is an urgent need for the systematic teaching of biostatistics, especially in the medical residency programs, which may include more specialized training so that the physicians can become more efficient in understanding biostatistics and clinical research thus, benefiting them for EBM practice. Further, the clinicians who are interested in research should form collaborations with statisticians to improve the quality of their work and enhance their statistical skills.

Declaration of Interest

The authors report no declarations of interest. The authors alone are equally responsible for the content of this article. This research work was funded by the King Fahad Medical City (IRF: 017-03).

Ethical Approval

Ethical approval was granted by Institutional Review Board, King Fahad Medical City (KFMC), Riyadh, Saudi Arabia.

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