Analysis of Statistical Knowledge of Peruvian Medical Students: A Cross-Sectional Analytical Study Based on a Survey

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Abstract: *Introduction*: Despite the growing awareness of the importance of knowledge in biostatistics, many investigations worldwide have found that medical students have a poor understanding of it.

Objective: To determine the percentage of Peruvian medical students with sufficient biostatistics knowledge and the associated factors.

Methods: Cross-sectional analytical study. Application of a virtual survey to medical students from different faculties in Peru.

Results: 56.46% of medical students have insufficient knowledge of biostatistics. A statistically significant association was found for those who were 25 years of age or older (aPR: 1.195; 95% CI 1.045 - 1.366; p=0.009); being between the 9th and 12th semester (aPR: 1.177; 95% CI 1.001 - 1.378; p=0.037) and medical internship (aPR: 1.373; 95% CI 1.104 - 1.707; p=0.004); take an external course in biostatistics, epidemiology or research (aPR: 4.016; 95% CI 3.438 - 4.693; p<0.001); having read more than 12 articles per year (aPR: 1.590; 95% CI 1.313 - 1.967; p<0.001); and publish at least one scientific article (aPR: 1.549; 95% CI 1.321 - 1.816; p<0.001) or more than one (PR: 2.312; 95% CI 1.832 - 2.919; p<0.001).

Conclusions: There is insufficient knowledge of biostatistics in medical students. The factors associated with a good understanding of this were age, academic semester, the number of articles read and published, and having taken an external course.

Keywords: Knowledge, Biostatistics, Students, Association, Peru, Medicine (Source: MeSH NLM).

1. INTRODUCTION

Biostatistics is the branch of statistics that uses statistical techniques and methods in the field of life sciences and health [1]. Therefore, its importance in teaching from the undergraduate level to its inclusion in postgraduate courses for health sciences students is crucial. Even though the relevance of teaching biostatistics to medical students has been recognized by the UK General Medical Council [2], the curricula for medical students, as in many Latin American countries, dedicate just under 2 hours a week to teaching this course.

The interest in understanding this topic is such that its absence may be responsible for the publication of biased research, underestimation, and overestimation of results, and misguided conclusions by pre-graduate and even post-graduate students. All of this could harm the practice of evidence-based medicine and healthcare [3-6].

However, despite the growing awareness of the importance of education in this discipline, scientific research has found that medical students have poor comprehension of common statistical tests and a limited ability to interpret study results. Worldwide, an adequate understanding of the analysis and results interpretation of scientific papers occurs in less than half of students and health professionals [7-11].

Therefore, given the need to know whether this behavior is also present in Peru, the objective of this study was to determine the percentage of Peruvian medical students with sufficient knowledge of biostatistics and the associated factors with it.

2. METHODS

2.1. Study Design

A cross-sectional analytical study was carried out through a virtual survey distributed from November 15, 2021, to February 15, 2022.

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2.2. Population, Sample, and Eligibility Criteria

The population was made up of medical students from human medicine faculties in Peru. The sample included those who agreed to participate in the study and those who reported residing in the country. Those who were in the first, second, and third semesters of the degree (by standardization, due to the probability of not having taken the biostatistics course), those under 18 years of age, and those who did not complete the questionnaire questions were excluded. Consecutive non-probabilistic sampling was carried out.

2.3. Variable Definition

The questionnaire contained two groups of questions: The first part consisted of 9 sociodemographic questions that included age; sex; Graduate School; external course in epidemiology, biostatistics, or research; reading of scientific articles; about the English language is a barrier to scientific reading; and the number of articles published.

The second part consisted of the biostatistics knowledge questions, created by Windish, Huot, and Green [7] and culturally adapted to our environment by Espinoza and Garcés [12]. 20 questions assessed understanding of biostatistical methods, study design, and interpretation of study results most frequently represented in our journal review. These questions were multiple-choice, clinically oriented with a case vignette, and did not require calculations. The variable was categorized dichotomously, and thus grouped into "sufficient knowledge" (≥ 11 points) versus "insufficient knowledge" (< 11 points).

2.4. Data Collection and Procedure

The research group decided to collect the data virtually. The survey was designed in Google Form, and strict quality control of the data captured was carried out through a pilot test. After that, the online survey was published on several social networks (Facebook, Twitter, and Whatsapp, among others) to contact university medical students during the period mentioned above. The approximate duration for filling out the form was 20 minutes per person. Then, a database was built in the Microsoft Excel 2016 program, where the collected data was entered.

2.5. Statistical Analysis

Statistical analysis was performed with STATA version 17.0 software. For the descriptive analysis, the qualitative variables were summarized in absolute and relative frequencies. In the bivariate analysis, the chi-square test of independence was performed.

A generalized linear model of the Poisson family with robust variance was used to obtain the crude prevalence ratio (CPR) and adjusted (aPR). It was considered statistically significant with the p-value <0.05 and the 95% confidence interval (95% CI) was presented.

3. RESULTS

It had the participation of 918 human medicine students. 6.10% had a medical internship. 23.97% had taken an external course in biostatistics, epidemiology, or research. During the last year, 40.74% had not read any article and 10.02% had published more than one manuscript. In general, 43.54% of medical students have sufficient knowledge of biostatistics. In the bivariate analysis, all the factors were found to be associated, except gender (p=0.597). The rest of the data is found in Table **1**.

In general, the question with the most correct answers was the one referring to the definition of bias (81.15%; 95% CI 78.49% - 83.56%), followed by the interpretation of the relative risk (67.54%; CI 95% 64.43% - 70.49%). However, the question with the fewest correct answers was the one that evaluated the interpretation of the p-value (25.49%, 95% CI 22.77% - 28.41%), followed by the interpretation of the Kaplan Meier analysis (37, 80%; CI95% 34.71% - 40.99%). The percentage of correct answers to the other questions can be seen in Table **2**.

Table **3** shows the multivariate analysis of each factor associated with knowledge of biostatistics. The variables used for adjustment were gender, categorized age, academic cycle, external course, number of articles read, and number of articles published. A statistically significant association was found for age among those 25 years of age or older (PRa: 1.195; 95% CI 1.045 - 1.366; p=0.009); being between the 9th and 12th semester (PRa: 1.177; 95% CI 1.001 - 1.378; p=0.037) and medical internship (PRa: 1.373; 95% CI 1.104 - 1.707; p=0.004) versus being in the 4th and 8th cycle; take an external course in biostatistics, epidemiology or research (PRa: 4.016; 95% CI 3.438 - 4.693; p<0.001); having read more than 12 articles per year (PRa: 1.590; 95% CI 1.313 - 1.967; p<0.001); and publish at least one scientific article (PRa: 1.549; 95% CI 1.321 - 1.816; p<0.001) or more than one (PR: 2.312; 95% CI 1.832 - 2.919; p<0.001).

Table 1: Characteristics and bivariate analysis related to Biostatistics' knowledge in the sample of medical students

		Knowledge in biostatistics		
	General characteristics n (%)	**Insufficient n (%)**	**Sufficient n (%)**	**p***
Sex				
Feminine	551 (60.02)	316 (57.35)	235 (42.65)	0.597
Masculine	367 (39.98)	204 (55.59)	163 (44.41)	
Categorized age				
18 to 24 years old	641 (69.60)	392 (61.15)	249 (38.85)	< 0.001
25 years or more	280 (30.40)	128 (45.71)	152 (54.29)	
Academic semester				
4th to 8th semester	560 (75.88)	335 (59.82)	225 (40.18)	< 0.001
9th to 12th semester	133 (18.02)	61 (45.86)	72 (54.14)	
medical internship	45 (6.10)	13 (28.89)	32 (71.11)	
The external course of biostatistics, epidemiology or research				
No	698 (76.03)	508 (72.78)	190 (27.22)	< 0.001
Yes	220 (23.97)	12 (5.45)	208 (94.55)	
Number of articles read in the year				
I have not read any	374 (40.74)	228 (60.96)	146 (39.04)	< 0.001
1 to 5 articles	122 (13.29)	67 (54.92)	55 (45.08)	
6 to 12 articles	324 (35.29)	196 (54.92)	128 (39.51)	
More than 12 articles	98 (10.68)	29 (29.59)	69 (39.51)	
The English language is a barrier				
No	341 (37.15)	154 (45.16)	187 (54.84)	< 0.001
Yes	577 (62.85)	366 (63.43)	211 (36.57)	
Number of articles published during the last year				
None	686 (74.23)	431 (62.83)	255 (37.17)	< 0.001
One	140 (15.25)	55 (39.29)	85 (60.71)	
More than 1	92 (10.02)	34 (36.96)	58 (63.04)	

*Analysis performed with the chi-square test of independence; p-value significative < 0.05.

Table 2: Percentages of correct answers to the Biostatistics knowledge questions

Question number	Objective	Correct % (IC 95%)
1a	Identifies continuous variables	61.22 (58.02 – 64.33)
1b	Identify ordinal variables	38.04 (33.97 – 40.22)
1c	Identifies nominal variables	73.64 (70.69 – 76.39)
2	Recognize the case and control study	63.72 (60.56 – 66.78)
3	Recognize the purpose of double-blind studies	44.55 (41.36 – 47.79)
4a	Identify the ANOVA analysis	41.39 (38.24 – 44.62)
4b	Identify chi-square analysis	52.29 (49.04 – 55.51)
4c	Identify Student's t-analysis	41.29 (38.14 – 44.51)
5	Recognize the definition of bias	81.15 (78.49 – 83.56)
6	Interpret the meaning of p-value < 0.05	25.49 (22.77 – 28.41)
7	Identify Cox regression analysis	44.12 (40.92 – 47.35)
8	Interpret the standard deviation	48.58 (45.35 – 51.82)
9	Interpret the confidence interval at 95% and the statistical significance	44.88 (41.68 – 48.12)
10	Recognizes the sample size, statistical power, and level of significance	42.37 (39.21 – 45.60)
11	Determine which test has more specificity	59.15 (55.93 – 62.29)

(Table 2). Continued.

Question number	Objective	Correct % (IC 95%)
12	Interpret an unadjusted odds ratio	45.21 (42.01 – 48.45)
13	Interpret an odds ratio in multivariate regression analysis	43.14 (39.96 – 46.37)
14	Interpret relative risk	67.54 (64.43 – 70.49)
15	Determine the strength of evidence for risk factors	47.38 (44.16 – 50.62)
16	Interpret Kaplan Meier analysis results	37.80 (34.71 – 40.99)

Table 3: Crude and adjusted Poisson regression analysis of the associated factors with knowledge in Biostatistics

	Bivariate analysis			Multivariable regression		
	CPR	**IC 95%**	**p**	**Apr**	**IC 95%**	**p**
Sex						
Feminine	Ref.			Ref.		
Masculine	1.041	0.896 – 1.210	0.596	1.069	0.939 – 1.217	0.316
Categorized age						
18 to 24 years old	Ref.			Ref.		
25 years or more	1.397	1.209 – 1.615	**< 0.001**	1.195	1.045 – 1.366	**0.009**
Academic semester						
4th to 8th semester	Ref.			Ref.		
9th to 12th semester	1.347	1.119 – 1.623	**0.002**	1.177	1.001 – 1.378	**0.037**
medical internship	1.770	1.432 – 2.188	**< 0.001**	1.373	1.104 – 1.707	**0.004**
The external course of biostatistics, epidemiology or research						
No	Ref.			Ref.		
Yes	3.473	3.063 – 3.938	**< 0.001**	4.016	3.438 – 4.693	**< 0.001**
Number of articles read in the year						
I have not read any	Ref.			Ref.		
1 to 5 articles	1.155	0.814 – 1.458	0.277	1.148	0.914 – 1.442	0.235
6 to 12 articles	1.012	0.841 – 1.218	0.899	1.094	0.937 – 1.277	0.254
More than 12 articles	1.804	1.506 – 2.160	**< 0.001**	1.590	1.313 – 1.967	**< 0.001**
Number of articles published during the last year						
None	Ref.			Ref.		
One	1.633	1.385 – 1.197	**< 0.001**	1.549	1.321 – 1.816	**< 0.001**
More than 1	1.696	1.410 – 2.039	**< 0.001**	2.312	1.832 – 2.919	**< 0.001**

*Adjusted for gender, categorized age, academic semester, external course, number of articles read, and number of articles published.
CPR: crude prevalence ratio. aPR: adjusted prevalence ratio. 95% CI: 95% confidence interval.

4. DISCUSSION

4.1. Main Findings

An insufficient level of knowledge on this subject was evidenced in medical students. The variables that showed association were categorized age, external course, a number of articles read, and having completed the internship. While the sex and the number of articles published were not.

4.2. Comparison with other Studies

Of the human medicine students surveyed, it was found that 43.54% understand the biostatistical results reported in the medical literature. This result coincides with studies carried out worldwide regarding insufficient knowledge on this subject. In the investigation of Torales *et al*. [13], only 4% of the participants scored above or equal to 60% (considered approved). Something very similar was found by Araoz-Melgarejo

et al. [14] in their work for seventh-year undergraduate students, and Susarla *et al.* [15], where the average percentage of correct answers in knowledge evaluations was 43.6%. The result found in this study was superior to the study carried out by emergency medicine residents in the USA (38%) [16], government hospital doctors in Malaysia (29,2%) [17], medical graduate students in India (38%) [18], maxillofacial surgery residents (38%) [19] and physicians residing in Saudi Arabia (33%) [20]. Furthermore, unlike another study where there was a non-negligible percentage (19%) of residents who had answered all the questions incorrectly [11], this did not occur in this study, since the minimum grade was 2.

The question aimed at correctly answering the concept of bias was the one that had the most correct answers (81.15%), and it was similar to other works [7,19]. Systematic error is one of the threats to the study's validity [21], this is elucidated from the beginning when criticizing an article, which explains why the notion of this is known. However, the question asking for the proper interpretation of the p-value was the one with the most incorrect answers, followed by the Kaplan Meier analyses. Knowledge specifically regarding the p-value has been studied in isolation, showing a low amount of positive response [22-24]. Nevertheless, in the study of Araoye *et al.* [25], 69% made an adequate interpretation of said value. On the other hand, advanced methods, such as survival analyses including Cox proportional hazards regression and Kaplan-Meier analyses, require more advanced knowledge, which would explain the reason why it also had a percentage of correct answers [26].

Sex was not associated with the level of knowledge. In a study conducted on family physicians, researchers found no sex differences [27]. In the same manner, other studies that evaluated the knowledge of biostatistics and epidemiology of physicians and interns did not make comparisons by sex [28,29]. Logic prevails in this since there should be no differences on this subject depending on whether you are a man or a woman.

Regarding the semester, internship students have greater knowledge of biostatistics, unlike in previous semesters. The explanation of this phenomenon is based on the fact that they are in the last year of medical training, where they must be constantly reading scientific articles, in turn having completed and approved all the research courses they have had throughout their degree [14].

Having read at least 12 articles throughout the year and published more than one article increased the chances of having greater knowledge in biostatistics. Numerous studies have found that critical reading allows knowing the different ways of presenting statistical analyses, although it would not be enough to read a few, it must be a continuous practice. While the publication allows the student to know the methods that are going to be carried out [30-32].

Having taken an external course in biostatistics, research or related increased the probability of having adequate knowledge of the subject. Previous literature has shown that previous courses in epidemiology or biostatistics were associated with greater confidence in assimilating and critically appraising the medical literature and in designing a research study [7]. It is even pointed out that taking short courses in biostatistics could make an important change in the knowledge of students and health professionals [33,34]. Furthermore, a study of Canadian obstetrics and gynecology residents found that 77% of residents felt little or no confidence in interpreting research statistics, and 84% were interested in receiving additional training in epidemiology [35]. Besides, these courses are not mandatory to finish the medical degree, so the interest in being part of it comes from the student, which makes him make more effort to learn, unlike when the course is part of the degree [36].

4.3. Limitations and Strengths of the Study

This study has both limitations and strengths. First, the questionnaire was expanded across all networks to access a wide range of medical students at different universities. Second, it is probable that those recruited would not belong to all the country's faculties, endangering representativeness; however, they must have similar characteristics, and equal access to information, so a certain inference can be made. Thirdly, although there are several questionnaires to assess knowledge in biostatistics, the one that, in the opinion of the authors of this manuscript, was the most complete and had cross-cultural validation in our environment was chosen, so the results may reflect what the true understanding of this subject is.

5. CONCLUSIONS

Medical students have insufficient knowledge of biostatistics. The factors associated with a good understanding were age, academic semester, several articles read and published, and having taken an

external course. If this is confirmed in future studies, it is necessary for educators to reevaluate and increase the biostatistical reasoning of medical students, as well as to emphasize and systematize the teaching of statistical concepts during their training period.

Ethical Aspects

The research work received the authorization of the Ethics Committee of the Medicine Faculty at Ricardo Palma University (Code: PI-008-2021). The information obtained did not violate the integrity of the study participants and during the investigation, the information confidentiality was maintained, and the responses collected were treated anonymously.

COMPETING INTEREST

The authors declared they do not have a potential conflict of interest and have not received financial funding from public or non-public institutions.

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AUTHORSHIP CONTRIBUTIONS

The authors participated in the genesis of the idea, project design, data collection and interpretation, analysis of results, and preparation of the manuscript of this research work.

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