Health Professions Education

Volume 6 | Issue 1 Article 10

2020-03-01

Assessment of Dental Faculty Members' Understanding of Statistical Concepts

Matthew J. Hayat
Department of Population Health Sciences, School of Public Health & Byrdine F. Lewis College of Nursing and Health Professions, Georgia State University, USA

MyoungJin Kim
Mennonite College of Nursing, Llinois State University, USA

Todd A. Schwartz
Department of Biostatistics, Gillings School of Global Public Health & School of Nursing, University of North Carolina at Chapel Hill, USA

Michael R. Jiroutek
Department of Clinical Research, Department of Pharmacy Practice (adjunct Appointment), College of Pharmacy & Health Sciences, Campbell University, USA

Recommended Citation

Hayat, Matthew J.; Kim, MyoungJin; Schwartz, Todd A.; and Jiroutek, Michael R. (2020) "Assessment of Dental Faculty Members' Understanding of Statistical Concepts," *Health Professions Education*: Vol. 6: Iss. 1, Article 10.
DOI: 10.1016/j.hpe.2019.09.002
Available at: https://hpe.researchcommons.org/journal/vol6/iss1/10

Available online at www.sciencedirect.com

ScienceDirect

Health Professions Education 6 (2020) 92–98

www.elsevier.com/locate/hpe

Assessment of Dental Faculty Members' Understanding of Statistical Concepts

Matthew J. Hayat [a,*], MyoungJin Kim [b], Todd A. Schwartz [c], Michael R. Jiroutek [d]

[a] *Department of Population Health Sciences, School of Public Health & Byrdine F. Lewis College of Nursing and Health Professions, Georgia State University, USA*

[b] *Mennonite College of Nursing, Llinois State University, USA*

[c] *Department of Biostatistics, Gillings School of Global Public Health & School of Nursing, University of North Carolina at Chapel Hill, USA*

[d] *Department of Clinical Research, Department of Pharmacy Practice (adjunct Appointment), College of Pharmacy & Health Sciences, Campbell University, USA*

Received 2 April 2019; revised 21 July 2019; accepted 3 September 2019
Available online 22 November 2019

Abstract

Purpose: Understanding the dentistry research literature is essential for maintaining best practices for evidence-based dentistry. Biostatistics knowledge is needed to accomplish this. The purpose of this study was to assess dentistry faculty knowledge of fundamental biostatistics concepts and methods.
Method: A random sample of U.S.-based dental schools was selected, and faculty assessed on their statistics knowledge. All faculty in each randomly selected school received an invitation to participate in an online survey that included demographic questions and a statistics knowledge assessment. Precision estimation was used to calculate the target sample size.
Results: Sixteen schools of dentistry were randomly selected and 2801 faculty sent email invitations. A total of 109 dentistry faculty responded. Most faculty (89.0%) reported reading the peer-reviewed health science literature. The mean (standard deviation) score on the knowledge assessment was 4.3 (2.3) out of 8 questions, a correct response rate of 52.3%. A multivariable linear regression model explained 33.8% of the variability in the number of correct responses.
Discussion: Biostatistics knowledge is important to critically evaluate evidence. These study results may be an indication that biostatistics educators need to re-evaluate the pedagogy of statistics instruction.

Keywords: Biostatistics; Dentistry research; Evidence-based practice

1. Introduction

Statistics coursework is often required for students pursuing a professional degree in dentistry.[1] Since dental research and practice literature make use of statistical concepts and methods in published reports, statistics education is essential for training students to critically read and evaluate study results, be it in

* Corresponding author. School of Public Health, Georgia State University, PO Box, 3984, Atlanta, GA, 30302-3894, USA. Fax: +404 413 1141.

E-mail address: mhayat@gsu.edu (M.J. Hayat).

Peer review under responsibility of AMEEMR: the Association for Medical Education in the Eastern Mediterranean Region.

https://doi.org/10.1016/j.hpe.2019.09.002

general or in specialty areas. For example, a critical review of 307 articles published between 1995 and 2009 in 10 peer reviewed dental research journals reported that 51.5% of the articles contained at least one statistical error.[2] Other similar studies of the dental literature have reported a multitude of issues with the use of statistics in the design and analysis of dental research.[3−7]

An assessment of statistics knowledge in Danish dentists completed 30 years ago found participants answered a median of 2.2 questions correctly on a 9-item statistical knowledge assessment (24.4% correct).[8] Only 35% of the practicing dentists in that study stated that statistics was a very important topic. Another study of oral and maxillofacial surgery residents found participants averaged 38% correct on a 6-item test of knowledge of statistical methods.[9] The authors in both studies concluded that dentists and residents lacked adequate knowledge in biostatistics and interpretations of research to comprehend or critically evaluate published clinical research. Few studies have assessed knowledge of dental professionals, and no known studies have quantified biostatistics knowledge for dental faculty.

Knowing which statistical methods are used in dental research is helpful in determining competencies needed for reading the literature. A study of publications in 4 dental research journals appearing between 1996 and 2006 quantified the types of statistical methods used and reported.[10] Those authors reported that the use of statistics was extensive and fundamental statistical concepts and methods were widely used throughout the time period studied.

The aim of this study was to conduct a preliminary investigation into dental faculty knowledge of fundamental statistical concepts. Such knowledge is needed in the practice of evidence-based dentistry, since it depends on the generation of new knowledge and evaluation of existing information to make informed clinical decisions. Biostatistics plays an essential role in developing evidence, assessing its value, and making data-informed decisions. Obtaining information about dental faculty members' knowledge of various statistical concepts will help to inform decision making about dental education curricula, as well as continuing education offerings.

2. Methods

The work presented here is part of a larger research investigation of health sciences faculty in schools of dentistry, medicine, nursing, pharmacy, and public health. Only details and results for dental faculty are presented in this article. Study findings for other disciplines will be published elsewhere.

An anonymous survey was developed that included questions about faculty characteristics and a statistics knowledge assessment consisting of eight questions about randomization, observational studies, statistical power, confidence intervals, multiple comparisons, standard error, regression response variables, and odds ratios (Appendix A). A multiple choice format was used for the knowledge questions. Each question had four answer choices, including the correct answer, two incorrect answers, and one choice to decline to guess the answer. Those that chose the option to decline to guess the answer to any question were considered as having an incorrect answer in all analyses. The survey was developed and administered online via Qualtrics.

The study population for dental faculty was comprised of a listing of 66 schools of dentistry accredited by the American Dental Association. Random selection was used to sample schools. Email addresses for all faculty at each randomly selected school were retrieved from the school website. Between April and August of 2017, we sent email invitations every other week in batches, each comprised of approximately 400 faculty. We continued sampling schools and sending out email invitations until our target sample size was achieved. Based on a precision estimation approach, our target sample size was 103 faculty. Approval was obtained from the Georgia State University and University of North Carolina at Chapel Hill Institutional Review Boards.

The sample size was determined using a precision estimation approach. We applied inversion of a classical confidence interval to determine the number of faculty within each discipline needed to estimate precision about the proportion of correct responses for each knowledge question. Since each question had 3 possible correct answers, the true probability of guessing the correct answer was 1 in 3, or 0.033. The half-width confidence interval of 0.10 for a two-side confidence interval around 0.33 yields 103 faculty needed. This was used as our target sample size to achieve adequate precision about the proportion of correct responses.

Summary statistics were generated for all study measures, including frequency distributions for categorical variables and means and standard deviations for continuous variables. The number of correct answers to eight statistics knowledge questions was computed and reported as the mean number of correct responses and the percentage correct. Given the central importance of each question topic in the use of statistics in the dental literature, we decided to apply equal weighting across items. These eight knowledge questions were assumed to contribute equally to the sum score. Linear regression modeling was used to explore the relationship between faculty characteristics and performance on the statistics knowledge assessment. Faculty characteristics significantly associated with the number of correct responses was retained in a multivariable model. The level of significance for this study was set at 0.05. SAS, version 9.4, was used for data analysis.

3. Results

Sixteen schools of dentistry were randomly selected, and invitations were sent to all 2801 faculty at the 16 selected schools. Adjusting for 216 returned emails or mail failure notices received, we estimate that 2585 faculty received invitations. A total of 109 faculty members responded, resulting in a 4.2% response rate.

Most of the study sample reported reading peer reviewed health related scientific journal articles (n = 98; 89.9%), and most viewed statistics as somewhat or very important in the researcher role (n = 100; 91.8%) (Table 1). Respondents were mostly female (n = 69; 63.3%) and half of the study sample (n = 55, 50.5%) had a clinical or practice doctorate degree. Participating faculty had a mean (standard deviation, SD) of 27.5 (11.6) years of professional experience, and 15.7 (11.6) years of experience as faculty. A third of respondents (n = 36, 33.0%) had completed 3 or more statistics or biostatistics courses, whereas 16 (14.5%) reported no courses on the topic. The majority (n = 99, 90.8%) of dental faculty respondents said they understood some or all of list of statistical expressions presented to them (e.g., standard deviation, standard error, p-values, confidence intervals, correlation coefficients).

The mean (SD) number of correct answers on the knowledge assessment was 4.3 (2.3), yielding 52.3% correct across the eight questions (Table 2). Aggregated scores on four of the eight questions resulted in less than 50% correct, including odds ratios (33.9%), randomization (34.9%), regression (40.5%), and statistical power (48.6%). Respondents scored slightly better on questions about describing an observational study (73.4%), understanding the relationship between the sample size and standard error (71.6%), and issues

Table 1
Faculty characteristics (n = 109).

Faculty Characteristic		Frequency (%)
Sex	Male	40 (36.7)
	Female	69 (63.3)
Highest Degree	Clinical/Practice doctorate	55 (50.5)
	Research doctorate	35 (32.1)
	Master's prepared	13 (11.9)
	Other	6 (5.5)
Professional time allocation percentage (sums to 100%)	Research	20.4 (24.9)
	Clinical work	28.5 (29.7)
	Teaching	32.3 (22.5)
	Other (Service, etc.)	18.8 (21.5)
Number of statistics/biostatistics courses completed	0	16 (14.5)
	1	32 (29.4)
	2	25 (22.9)
	3+	36 (33.0)
Number of epidemiology courses completed	0	49 (45.0)
	1	34 (31.2)
	2	13 (11.9)
	3+	13 (11.9)
Teaches statistics/biostatistics	Yes	12 (11.0)
	No	97 (89.0)
Rating of importance of statistics in role as a researcher	Very important	67 (61.5)
	Somewhat important	33 (30.3)
	Not important	9 (8.3)
Reads peer-reviewed health-related scientific journal articles	Yes	98 (89.9)
	No	11 (10.1)
Attitude about fundamental statistical concepts	Understands some/all expressions	99 (90.8)
	Understands little/none expressions	10 (9.2)

with multiple testing (60.6%). The frequency and percent opting out of guessing for each question are also displayed in Table 2.

Table 3 displays multiple linear regression modeling results with the number of correct responses as the dependent variable and faculty characteristics as explanatory variables. Statistically significant independent variables were retained in the displayed multivariable model. Number of epidemiology courses completed and professional time allocation were not retained. Regression diagnostics were examined and assumptions verified. Correlations and tolerance results confirmed lack of multicollinearity. Having a research doctorate (b = 0.93, 95% CI [0.03,1.83], p = .0422), teaching statistics or biostatistics (b = 1.81, 95% CI [0.49,3.13], p = .0076), reading the literature (b = 1.45, 95% CI [0.04,2.85], p = .0436), number of years of professional experience (b = −0.05, 95% CI [-0.10,-0.01], p = .0174), completing 3 or more biostatistics courses (b = 1.50, 95% CI [0.59, 2.41], p = .0014), and number of years of experience as a faculty member (b = 0.05, 95% CI [0.002,0.09], p = .0408) were associated with number of correct responses in a multivariable sense. The statistical model explained 33.8% of the variability in the dependent variable.

Table 2
Percentage of correct responses on statistics knowledge assessment and frequency of opting out for guessing (n = 109).

Statistics Knowledge Questions	Frequency Opting out of Guessing *Count (%)*	Percentage of Correct Responses *Percent (SD[a])*
Describing an observational study.	8 (7.3)	80 (73.4)
Relationship between the sample size and standard error.	15 (13.8)	78 (71.6)
Understanding the issue with multiple testing.	28 (25.7)	66 (60.6)
Interpreting a confidence interval.	19 (17.4)	58 (53.2)
Defining statistical power.	28 (25.7)	53 (48.6)
Understanding the difference between linear and logistic regression.	19 (17.4)	55 (40.5)
Understanding the rationale for randomization.	50 (45.9)	38 (34.9)
Interpreting an odds ratio.	26 (23.9)	37 (33.9)
Number of correct answers on 8 knowledge questions, mean (SD[a])		4.3 (2.3)
Percentage correct		52.3%

[a] SD = standard deviation.

Table 3
Multiple linear regression modeling results for explaining the number of correct responses (dependent variable) as a function of significant faculty characteristics (independent variables) (n = 109)*.

Faculty Characteristic		Parameter Estimate	95% Confidence Interval		p-value
			Lower	Upper	
Years of professional experience		−0.05	−0.10	−0.01	0.0174
Years as a faculty member		0.05	0.002	0.09	0.0408
Research Doctorate	Yes	0.93	0.03	1.83	0.0422
	No	Reference			
Biostatistics courses completed	3+	1.50	0.59	2.41	0.0014
	<3	Reference			
Teaches statistics/biostatistics	Yes	1.81	0.49	3.13	0.0076
	No	Reference			
Reads peer-reviewed health-related	Yes	1.45	0.04	2.85	0.0436
scientific journal articles	No	Reference			

* The covariates explained 33.8% of the variability of number of correct responses in this model (r^2= 0.338).

4. Discussion

The dismal 4.2% response rate may be indicative of potential bias in our study sample. Since 92% of the participants reported believing statistics to be somewhat or very important, it is possible that dental faculty in the population do not consider statistics as important as the faculty who responded to the survey. Also, 90% of respondents reporting reading the scientific literature. We expect that faculty reading the literature and placing importance on the topic are more likely to be more knowledgeable about statistics. If this is true, dental faculty in our study likely demonstrated higher levels of statistics knowledge than may be found with other dentistry faculty.

Faculty with a research doctorate that read the peer-reviewed scientific literature showed significantly higher levels of statistics knowledge. As expected, faculty teaching statistics or biostatistics answered almost 2 more questions correctly as compared to those not teaching the topic. While years of experience as a faculty member was positively associated with answering questions correctly, overall years of professional experience was negatively associated. This may be reflective of the group of dentistry faculty that worked in clinical practice and later transitioned into an academic position and role, though we do not have the data to confirm this. Faculty in a research intensive higher education environment may be more likely to encounter statistical concepts and methods than clinicians in practice.

While these study findings likely over-estimate levels of statistics knowledge, this provokes thought about the measured performance by the respondents. Each knowledge question had three non-guessing answers to choose from. Thus, true guessing would yield an expected score of 33%. The scores on items about randomization, regression, and odds ratio were in line with guessing. About 35% of faculty correctly answered the question about randomization. Previous research that suggests most dental research studies are observational in nature.[10] Thus, it could be that randomized controlled trials are not as frequently reported as observational studies. Interestingly, the majority of respondents (73%) were able to respond correctly on the item regarding an observational study.

The results of this study are suggestive at best about biostatistics competency with dentistry faculty. Certainly, the focus on evidence-based practice in dental education is present throughout the coursework and curriculum. For this reason, dental faculty need to be well-versed in fundamental statistical concepts to speak knowledgeably about evidence and its interpretation. The findings presented may be reflective of a need for biostatistics educators to reflect and evaluate the pedagogy and effectiveness of statistics instruction. Improved education and training in these fundamental statistical concepts is essential for future dental faculty and dental professionals to develop skill and ability to read and comprehend the scientific literature as well as contribute to it.

Ethical approval

Approval was obtained from the Georgia State University and University of North Carolina at Chapel Hill Institutional Review Boards.

Funding

This was unfunded work.

Other disclosures

There were no conflicts of interest.

Declaration of Competing Interest

The authors declare no conflict of interest and no competing interests.

Appendix A.

Assessment of Statistics Knowledge in the Health Sciences.

1. Which reflects your attitude about statistical concepts (e.g., standard deviation, standard error, p-values, confidence intervals, correlation coefficients)?
   a. I understand all of these expressions.
   b. I understand some of these expressions.
   c. I understand little of these expressions.
   d. I do not understand these expressions.
2. What is the rationale for random allocation in a randomized controlled trial?
   a. **To produce treatment groups with similar characteristics.**
   b. To ensure all subjects had an equal chance of being selected for inclusion in the study.
   c. To increase the accuracy of the research results.

d. I'm not confident with my knowledge about randomization and do not want to guess.

3. Which of the following is most correct in describing an observational study?
   a. A researcher can control how subjects are assigned to groups.
   b. **The independent variable is not under the control of the researcher.**
   c. The independent variable is under the control of the researcher.
   d. I'm not confident with my knowledge about observational studies and do not want to guess.
4. Which of the following best describes statistical power?
   a. Ineffective treatment is found to be ineffective.
   b. Effective treatment is declared ineffective.
   c. **Effective treatment is declared effective.**
   d. I am not familiar with statistical power and do not want to guess.
5. How would you interpret a 95% confidence interval for the true mean of a numeric health outcome?
   a. You can be 5% confident that the interval will not include the true mean.
   b. You can be 95% confident that the interval will include the true mean.
   c. **If you draw repeated random samples and calculate a confidence interval for each, you can expect 95% of the intervals to contain the true mean.**
   d. I do not understand the expression and do not want to guess.
6. Which of the following is correct if one of 15 t-tests is significant at the 0.05 level?
   a. This is a result worthy of publication.
   b. **You should exercise caution in interpreting this single significant finding, since the Type I error rate is likely inflated due to multiple testing.**
   c. You should consider a different statistical analysis since you only have one statistically significant result.
   d. I do not understand the expression and do not want to guess.
7. What is your understanding of how the standard error will change as the sample size increases?
   a. **Standard error will decrease.**
   b. Standard error will remain the same.
   c. Standard error will increase.
   d. I do not understand the expression and do not want to guess.
8. Which of the following best describes the primary difference between linear regression and logistic regression?
   a. The dependent variable is categorical in a linear regression while it is continuous in logistic regression.
   b. **The dependent variable is continuous in a linear regression while it is categorical in logistic regression.**
   c. They serve the same purpose so can be used interchangeably.
   d. I do not understand regression and do not want to guess.
9. What is the most correct interpretation of an odds ratio of 3.0?
   a. There is a statistically significant association (at the 0.05 level) between the exposure and the outcome.
   b. The likelihood of the event is 3 times higher in one group than another.
   c. **The odds of the event is 3 times as high in one group as in the other.**
   d. I do not understand odds ratios and do not want to guess.
10. How important is understanding of statistical concepts for you in your role as a researcher?
   a. Very important
   b. Somewhat important
   c. Not important

References

1. Kim JS, Dailey RJ. *Biostatistics for oral healthcare*. Ames, IA: Wiley-Blackwell Publishing; 2007.
2. Kim JS, Kim D-K, Hong SJ. Assessment of errors and misused statistics in dental research. *Int Dent J*. 2011;61:163−167.
3. Kim JS. Misused statistics in dental research and challenges of teaching statistics. *Loma Linda University Dentistry Alumni Magazine*. 2010;21:11−16.
4. Hannigan A, Lynch CD. Statistical methodology in oral and dental research: pitfalls and recommendations. *J Dent*. 2013 May;41(5):385−392.
5. Baccaglini L, Shuster JJ, Cheng J, et al. Design and statistical analysis of oral medicine studies: common pitfalls. *Oral Dis*. 2010 Apr;16(3):233−241.
6. Tu YK, Kellett M, Clerehugh V, et al. Problems of correlations between explanatory variables in multiple regression analyses in the dental literature. *Br Dent J*. 2005 Oct 8;199(7):457−461.
7. Fleming PS, Koletsi D, Polychronopoulou A, et al. Are clustering effects accounted for in statistical analysis in leading dental specialty journals? *J Dent*. 2013 Mar;41(3):265−270.

8. Scheutz F, Andersen B, Wulff HR. What do dentists know about statistics? *Scand J Dent Res*. 1988 Aug;96(4):281−287.
9. Best AM, Laskin DM. Oral and maxillofacial surgery residents have poor understanding of biostatistics. *J Oral Maxillofac Surg*. 2013 Jan;71(1):227−234.
10. Vähänikkilä H, Nieminen P, Miettunen J, et al. Use of statistical methods in dental research: comparison of four dental journals during a 10-year period. *Acta Odontol Scand*. 2009;67(4):206−211.

Matthew J. Hayat, PhD, MS. Dr. Hayat is a Professor of Biostatistics in the Department of Population Health Sciences in the School of Public Health at Georgia State University. He has more than twenty years of experience as a senior collaborating biostatistician and statistics educator.

Myoung Jin Kim, PhD. Dr. Kim is a Professor of Biostatistics in the Mennonite College of Nursing at Illinois State University. He is a senior biostatistician and provides consultation to faculty on applied health research studies, as well as teaches statistics to graduate health science students. He is the author of a leading textbook on the use of statistics for doctorally trained clinicians.

Todd A. Schwartz, DrPH. Dr. Schwartz is an Associate Professor of Biostatistics in the Department of Biostatistics, Gillings School of Global Public Health and School of Nursing, at University of North Carolina at Chapel Hill. He has led a number of efforts and publications on statistics education for health sciences faculty and students.

Michael R. Jiroutek, DrPH, MS. Dr. Jiroutek is an Associate Professor of Biostatistics in the Department of Clinical Research, College of Pharmacy & Health Sciences, at Campbell University. He has more than twenty years of experience in industry and academia and published on statistics education for health scientists.