Original Article

The Trend of Analytical Approaches in Dental Research

Kawin Sipiyaruk[1], Tawepong Arayapisit[2], Patsachol Patthanajitsilp[3], Pichaya Tangpanchasil[3], Laksika Sukcharoenmitr[3], Anthony Hayter[4], Natchalee Srimaneekarn[2]

[1]Department of Orthodontics, [2]Department of Anatomy, [3]Mahidol International Dental School, Faculty of Dentistry, Mahidol University, Bangkok, Thailand, [4]Department of Business Information and Analytics, University of Denver, Denver, Colorado, USA

Received : 30-12-20
Revised : 01-03-21
Accepted : 09-04-21
Published : 30-07-21

ABSTRACT

Objectives: The aims of this article are to examine statistical approaches employed in international dental articles published in 2018 and 2019, as well as to examine relationships among analytical approaches, journal rankings, and types of research. **Materials and Methods:** International dental journals published in 2018 and 2019 were selected from the four quartiles (Q1–Q4) of journal rankings using a stratified random sampling. All original articles in a randomly sampled issue of each selected journal were reviewed to explore employed statistical approaches and to examine relationships among analytical approaches, journal rankings, and types of research. **Results:** One hundred and twenty-eight English-written international journals listed according to SCImago Journal Rank were selected, consisting 969 original articles. Significant differences in the use of statistics were found among the four quartiles and between types of research. The articles in Q1 tended to use more advanced analysis but lower descriptive analytics than other quartiles. The narrative approach was highly used in laboratory-based articles (18.66%), whereas clinical research was likely to use more descriptive (92.32%) and advanced analyses (26.30%). The data also found no remarkable differences in the patterns of the three most common statistical use among the four quartiles. **Conclusion:** This research revealed statistical use in international dental journals, which will enable educators to consider statistical content to be included in dental curricula, either for undergraduate or for postgraduate programs.

Keywords: *Data analytics, dental education, dental research, dentistry, outcome-based education, statistics*

Introduction

Following the rapid growth of computer technologies, digital innovation has been driven to be a global imperative. The development of computing and informatics has impact on the role of statistics, in which statistical approaches have become more robust and effective.[1] The advancement of data analytics recently plays a significant role in a variety of areas including healthcare. For instance, prevention of errors in diagnosis and treatment, following the improvement of decision-making process, seems to be one of the important benefits of data analytics.[2] Therefore, the implementation of statistics is unavoidable in healthcare professions including dental education.

Statistics instruction has been implemented in dental curricula for a long period of time. Several studies suggested that statistics was required for dental training.[3-5] However, the implementation of statistical instruction in dental schools is complicated. There were many factors affecting performance in statistics of dental students, and a variety of teaching methods should

Address for correspondence: Dr Natchalee Srimaneekarn, Department of Anatomy, Faculty of Dentistry, Mahidol University, 6 Yothi Road, Ratchathewi, Bangkok 10400, Thailand. E-mail: natchalee.sri@mahidol.edu

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_444_20

How to cite this article: Sipiyaruk K, Arayapisit T, Patthanajitsilp P, Tangpanchasil P, Sukcharoenmitr L, Hayter A, Srimaneekarn N. The trend of analytical approaches in dental research. J Int Soc Prevent Communit Dent 2021;11:463-8.

be arranged to match their learning preferences.[6] In addition, there was evidence that perceived knowledge of clinicians in biostatistical concepts was quite low, although they considered biostatistics important for clinical practice.[7] These arguments support the need of statistical training in dental education; however, further improvements should be considered to enhance competence in statistics for dental graduates.

Learning outcomes of statistical education for dental curricula should be considered. Learning outcomes are a set of skills or knowledge that students are required to achieve at the end of any course or program.[8,9] According to a textbook called "Fundamentals of Biostatistics," several analytical approaches are described ranging from descriptive to inferential statistics, covering both univariable and multivariable analyses.[10] This statistical textbook has been used for statistical courses in top healthcare universities, such as Harvard University,[11] University of California, Los Angeles,[12] University of Arizona,[13] and Karolinska Institute.[14] However, these statistical courses are likely to emphasize on univariable analysis rather than multivariable analysis. This implies that the book seems to have statistical content required for healthcare undergraduates.

According to the concept of outcome-based education, learning outcomes of a statistical course should represent what students are required to achieve to pursue their dental career. Should univariable analyses be not competent to analyze multiple variables, some valuable perspectives of findings may be absent. Moreover, basic statistical approaches provided in a textbook might not be sufficient for dental students, as evidence shows that advanced statistics are required for modern healthcare analytics.[2] Multivariable analyses and more advanced statistics may be required for recent dental undergraduates. However, there is no evidence to support this argument. Consequently, to inform what statistic content should be included, this research was conducted to explore statistical approaches employed in dental research published in international journals and to examine relationships among analytical approaches, journal rankings, and types of research.

Materials and Methods

This study conducted a quantitative-based cross-sectional research design to collect data of statistical approaches of international dental articles published in 2018 and 2019. This technique allowed the researchers to survey existing data from a great number of sources.

The journals were included in this study if they were international journals in dentistry subject area, according to SCImago Journal Rank (SJR) in 2018 and 2019. However, this research excluded journals which allowed publications in languages other than English. Afterwards, the included journals were selected using a stratified random sampling, considering quartiles as strata. According to the SJR, a set of journals has been ranked within a discipline and divided into four quartiles, ranging from Q1 to Q4, and therefore there were four strata. Q1 included journals whose rankings are in the top 25% of its subject category, whereas Q4 is occupied by journals in the bottom 25%. The sample size was calculated for each stratum using a finite population formula. For each selected journal, only one issue in each year was selected using a simple random sampling; all original articles published in the selected issues were then included into the analysis of this research.

The data extracted from each article included analytical approaches, which were classified into four categories: (1) narrative analysis, (2) descriptive statistics, (3) univariable statistics, (4) multivariable statistics, and (5) advanced statistics. The advanced statistics referred to any statistical approaches which were not described in dental curriculum based on the textbook "Fundamentals of Biostatistics,"[10] as they might be initially considered not necessary for dental undergraduates. The articles were also considered whether they were laboratory-based or clinical research.

The data were analyzed using the frequency to present the three most common analytical approaches of univariable, multivariable, and advanced analyses in each quartile. Cramer's V coefficient was used to explore relationships among analytical approaches, journal rankings, and types of research. As an article could employ more than one analytic approach, the relationships between data analytics and other variables needed to be conducted individually. The significance was taken at $p<0.05$ with Bonferroni adjustment for pairwise.[15] The effect sizes of Cramer's V were interpreted according to Akoglu.[16]

Results

This research identified 412 international journals published in a dentistry subject area according to the SJR, which were 201 and 211 articles in 2018 and 2019, respectively. After consideration of the exclusion and inclusion criteria, 68 (33 in 2018 and 35 in 2019) journals were excluded, as they allowed publications in languages other than English, or they were not ranked in any quartiles. With stratified random sampling, 63 journals in 2018 and 65 journals in 2019 were selected for this study. Following simple random sampling to select an issue from each journal, 486 and 483 articles from the journals published in 2018 and 2019, respectively, were analyzed in this study. These data are presented in Table 1.

According to Table 2, the types of analytical approaches in each quartile were analyzed. The data demonstrated that the trend of analytical approaches employed in international dental journals was similar in 2018 and 2019. The most common analytical approaches were descriptive, followed by univariable, advanced, and multivariable analyses. In addition, the journal rankings over the two years were found to be strongly correlated with descriptive statistics (2018: $p<0.001$, Cramer's $V=0.257$; 2019: $p=0.001$, Cramer's $V=0.187$; 2018–2019: $p<0.001$, Cramer's $V=0.228$) and advanced analysis (2018: $p<0.001$, Cramer's $V=0.241$; 2019: $p=0.01$, Cramer's $V=0.154$; 2018–2019: $p<0.001$, Cramer's $V=0.211$). As there appeared to be the same trend of analytical approaches in both years, the following results will be described using the data from over the two years (2018–2019).

According to the Bonferroni adjustment for pairwise analyses, there were statistically significant differences in the application of descriptive analysis between Q1 and other quartiles in 2018–2019 ($p<0.001$, Cramer's $V=0.185$, 0.213, 0.218 for comparisons with Q2, Q3, and Q4, respectively), whereas the use in Q2, Q3, and Q4 was not significantly different ($p>0.05$). This type of statistics was used the least in Q1 (77.22%), followed by Q2 (91.20%), Q3 (93.30%), and Q4 (94.90%). In contrast to the descriptive analysis, there were statistically significant differences in the use of advanced analysis between Q1 and other quartiles ($p<0.001$, Cramer's $V=0.154$, 0.214, 0.222 for comparisons with Q2, Q3, Q4, respectively), but it was employed in Q1 the most (34.02%). No statistically significant differences were found in the use of advanced analysis among Q2, Q3, and Q4. In addition, the use of narrative, univariable, and multivariable analyses was not significantly different among those quartiles ($p=0.350$, 0.066, and 0.162, respectively).

Table1: International journals in a dentistry subject area in 2018 and 2019

Quartiles	Populations	Included journals	Selected journals	Number of articles
2018				
Q1	54	52	17	164
Q2	49	43	16	127
Q3	50	45	16	104
Q4	47	28	14	91
No Q	1	0	0	0
Total	**201**	**168**	**63**	**486**
2019				
Q1	54	52	17	174
Q2	54	50	17	123
Q3	50	41	16	120
Q4	50	33	14	66
No Q	3	0	0	0
Total	**211**	**176**	**65**	**483**

When considering the frequency of each statistical approach [Table 3], for the univariable analysis group, the three most common analyses were χ^2 test, independent sample *t*-test, and one-way analysis of variance (ANOVA). The patterns of statistical use were not likely to be different among the four quartiles. According to the multivariable analysis group, linear regression, logistic regression, and two-way ANOVA were the three most common approaches. The three most common approaches in the advanced analysis group were survival analysis, repeated-measures ANOVA, and mixed-effect model.

This study also compared the use of statistics in laboratory-based (conducted under highly controlled conditions) and clinical research [Table 4]. The findings demonstrated that there were statistical differences in the use of narrative ($p<0.001$, Cramer's $V=0.207$), descriptive ($p<0.001$, Cramer's $V=0.199$), and advanced analyses ($p=0.001$, Cramer's $V=0.132$) between the two types of research. The narrative approach was highly used in laboratory-based research articles (18.66%). However, clinical research was likely to use more descriptive and advanced analyses (92.32% and 26.30%, respectively). No significant difference was found in the use of univariable analyses ($p=0.072$) and multivariable analyses ($p=0.076$).

Discussion

This study found that there were significant differences in the use of statistical approaches among journal rankings in dentistry. Unsurprisingly, the percentage in the use of advanced statistics was significantly higher in Q1, compared with other journal rankings. Several complex issues cannot be answered with simple research designs, and advanced statistics were required to suit those complicated data.[17] According to the descriptive analysis, the proportion of research studies in Q1 using descriptive analysis was significantly lower than that of the other quartiles. This could be a result of the high percentage in the use of advanced analyses in Q1, as descriptive analytics might not be necessary to construct understanding for the data from the advanced statistics.

When considering the pattern of statistical approaches used in each quartile, there seemed to be no differences in the three most frequent use for univariable,

Table 2: Analytical approaches employed in international dental journals in 2018 and 2019

Quartile		Total	Narrative	Descriptive	Univariable	Multivariable	Advanced
Year 2018							
1	*n*	164	18	122[a]	123	34	61[a]
	(% within Q1)	(100.00)	(10.98)	(74.39)	(75.00)	(20.73)	(37.20)
2	*n*	127	17	117[b]	99	23	29[b]
	(% within Q2)	(100.00)	(13.39)	(92.13)	(77.95)	(18.11)	(22.83)
3	*n*	104	11	97[b]	86	13	15[b]
	(% within Q3)	(100.00)	(10.58)	(93.27)	(82.69)	(12.50)	(14.42)
4	*n*	91	6	85[b]	78	9	11[b]
	(% within Q4)	(100.00)	(6.59)	(93.41)	(85.71)	(9.89)	(12.09)
p-value			0.461	<0.001	0.171	0.089	<0.001
Cramer's *V*			0.073	0.257	0.102	0.116	0.241
Year 2019							
1	*n*	174	17	139[a]	119	31	49[a]
	(% within Q1)	(100.00)	(9.77)	(79.89)	(68.39)	(17.82)	(28.16)
2	*n*	123	5	111[b]	93	15	21[b]
	(% within Q2)	(100.00)	(4.07)	(90.24)	(75.61)	(12.20)	(17.07)
3	*n*	120	6	112[b]	94	17	18[b]
	(% within Q3)	(100.00)	(5.00)	(93.33)	(78.33)	(14.17)	(15.00)
4	*n*	66	3	64[b]	52	11	9[b]
	(% within Q4)	(100.00)	(4.55)	(96.97)	(78.79)	(16.67)	(13.64)
p-value			0.159	0.001	0.173	0.577	0.010
Cramer's *V*			0.104	0.187	0.102	0.064	0.154
All							
1	*n*	338	35	261[a]	246	65	115[a]
	(% within Q1)	(100.00)	(10.36)	(77.22)	(72.78)	(19.23)	(34.02)
2	*n*	250	22	228[b]	192	38	50[b]
	(% within Q2)	(100.00)	(8.80)	(91.20)	(76.80)	(15.20)	(20.00)
3	*n*	224	17	209[b]	180	30	33[b]
	(% within Q3)	(100.00)	(7.59)	(93.30)	(80.36)	(13.39)	(14.73)
4	*n*	157	9	149[b]	129	20	20[b]
	(% within Q4)	(100.00)	(5.73)	(94.90)	(82.17)	(12.74)	(12.74)
p-value			0.350	<0.001	0.066	0.162	<0.001
Cramer's *V*			0.058	0.228	0.086	0.073	0.211

Different superscript letters indicate statistically significant difference

multivariable, and advanced analyses among those four quartiles. These data reflected the necessary to include those statistical approaches into a statistical course for dental curricula. For instance, if advanced statistics should be required for a dental program, a course director may decide to include survival analysis, repeated-measures ANOVA, mixed-effect model, and factor analysis, as presented in the standard statistics textbooks,[17-19] rather than other statistical approaches. Furthermore, although there is no plan to include any of the advanced statistics, these data can also enable dental educators to select basic statistical approaches for the emphasis of the course.

The findings also demonstrated statistically significant higher percentage of the use of advanced statistics in clinical research, compared with laboratory-based studies. This could be resulted from the fact that research environment can be conveniently controlled in a laboratory, causing that there are fewer variables to be considered. In contrast, it is quite inconvenient to control environments in clinical settings, and therefore, there are many variables into considerations, compared with laboratory-based research. As a result, advanced statistics are likely to be employed in clinical research. This suggestion would be helpful for educators in designing a statistics course for a dental curriculum by considering whether it is laboratory-based or clinical program, according to the concept of outcome-based education.

It could be seen that, in addition to descriptive analysis, univariable statistics were likely to be used for the articles in all of the four quartiles (approximately 80%). The findings implied that these statistics were considered quite necessary as basic statistics for dental students, dentists, researchers, and academic staff. This information was concurrent to learning

Table 3: The three most frequency of statistical approaches in international dental journals

Univariable analysis	*n*	%	Multivariable analysis	*n*	%	Advanced analysis	*n*	%
Q1 (*n*=338)								
Chi-square test	77	22.78	Linear regression	31	9.17	Survival analysis	39	11.54
Independent sample *t*-test	73	21.60	Logistic regression	26	7.69	Mixed-effects model	24	7.10
One-way ANOVA	69	20.41	Two-way ANOVA	12	3.55	Repeated-measures ANOVA	17	5.03
Q2 (*n*=250)								
Independent sample *t*-test	61	24.40	Linear regression	17	6.80	Survival analysis	19	7.60
Mann–Whitney	57	22.80	Logistic regression	17	6.80	Repeated-measures ANOVA	11	4.40
Chi-square test	54	21.60	Two-way ANOVA	9	3.60	Factor analysis	5	2.00
Q3 (*n*=224)								
Chi-square test	58	25.89	Two-way ANOVA	15	6.7	Survival analysis	17	7.59
Independent sample *t*-test	56	25.00	Linear regression	13	5.8	Repeated-measures ANOVA	7	3.13
One-way ANOVA	49	21.88	Logistic regression	12	5.36	Mixed-effects model	5	2.23
Q4 (*n*=157)								
Chi-square test	41	26.11	Two-way ANOVA	7	4.46	Repeated-measures ANOVA	9	5.73
One-way ANOVA	32	20.38	Linear regression	6	3.82	Survival analysis	8	5.1
Independent sample *t*-test	29	18.47	Logistic regression	4	2.55	Mixed-effects model	3	1.91
Total (*n*=969)								
Chi-square test	230	23.74	Linear regression	67	6.91	Survival analysis	83	8.57
Independent sample *t*-test	219	22.6	Logistic regression	59	6.09	Repeated-measures ANOVA	44	4.54
One-way ANOVA	200	20.64	Two-way ANOVA	43	4.44	Mixed-effects model	36	3.72

Table 4: Analytical approaches employed in laboratory-based or clinical research

Type		Total	Narrative	Descriptive	Univariable	Multivariable	Advanced
Clinical study	*n*	521	29	481	389	93	137
	(%)	(100.00)	(5.57)	(92.32)	(74.66)	(17.85)	(26.30)
Laboratory-based study	*n*	284	53	223	228	37	42
	(%)	(100.00)	(18.66)	(78.52)	(80.28)	(13.03)	(14.79)
p-value			<0.001	<0.001	0.072	0.076	<0.001
Cramer's *V*			0.207	0.199	0.063	0.063	0.132

content of several textbooks used for statistics courses in undergraduate programs,[10,20,21] which commonly include Chi-square test, independent sample *t*-test, one-way ANOVA, and Mann–Whitney analyses. Consequently, they should be required for a statistical course in dental curricula at all levels, especially for an undergraduate program.

The data of this research would allow educators and academic staff to decide which statistics should be emphasized for dental students; however, due to a large amount of data retrieved for this research, only analytics approaches used in articles published in 2018 and 2019 were analyzed to compare their use among the four quartiles. It would be helpful for further research to retrospectively explore data in several years to explore trends in the use of statistics. This could enable educators to predict the popularity of statistics and design statistical courses, purposing learners to implement the learning content for the future use. Furthermore, not only these four quartiles of international journals but also other publications including gray literature (e.g. dissertations and theses) should be included into consideration, which would help building an idea which statistics should be focused in general.

Conclusion

In summary, significant differences in the use of statistics among the four quartiles according to the SJR were found. Research articles in Q1 were likely to use advanced statistics more frequently than other quartiles. The trends of statistical use of advanced statistics were nearly similar among those four quartiles, which were survival analysis, repeated-measures ANOVA, mixed-effect model, and factor analysis. Consequently, in case that advanced statistics can be arranged for dental curricula, those four statistics could be emphasized. In addition, as there appeared to be a frequent use of descriptive analysis and univariable statistics in all quartiles, they should be considered as basic requirements for a statistical course for all dental curricula. However, further retrospective research should be conducted in several years to predict the popularity of future statistical use.

Acknowledgements

We would like to thank Faculty of Dentistry, Mahidol University, Thailand for the funding support.

Financial support and sponsorship

This research was supported by Faculty of Dentistry, Mahidol University, Thailand.

Conflicts of interest

There are no conflicts of interest.

Authors contributions

Kawin Sipiyaruk: Definition of intellectual content, data analysis, manuscript preparation, manuscript editing and review. Tawepong Arayapisit: Design, definition of intellectual content, experimental studies, manuscript editing and review. Patsachol Patthanajitsilp: Experimental studies, data acquisition, data analysis, manuscript preparation. Pichaya Tangpanchasil: Experimental studies, data acquisition, data analysis, manuscript preparation. Laksika Sukcharoenmitr: Experimental studies, data acquisition, data analysis, manuscript preparation. Anthony Hayter: Concepts, design, definition of intellectual content, manuscript editing and review. Natchalee Srimaneekarn: Design, experimental studies, statistical analysis, manuscript preparation.

Ethical policy and institutional review board statement

Certificate of excemption: COE.No.MU-DT/PY-IRB 2019/049.2608.

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

References

1. Snee RD. Discussion: Development and use of statistical thinking: A new era. Int Statist Rev/Revue Internationale de Statistique 1999;67:255-8.
2. Islam MS, Hasan MM, Wang X, Germack HD, Noor-E-Alam M. Systematic review on healthcare analytics: Application and theoretical perspective of data mining. Healthcare 2018;6:54.
3. Hutton JG Jr, Levy RA, Martin HB. An alternative approach to teaching statistics to dental students. J Dent Educ 1982;46:147-52.
4. Ling J, Fu Y. Recent changes in the curriculum of Chinese dental schools. J Dent Educ 2007;71:1447-56.
5. Smeeton N. Undergraduate courses in dental statistics in Britain and Ireland. Statist Educ Res J 2002;1:45-8.
6. El Tantawi MM. Factors affecting postgraduate dental students' performance in a biostatistics and research design course. J Dent Educ 2009;73:614-23.
7. West CP, Ficalora RD. Clinician attitudes toward biostatistics. Mayo Clin Proc 2007;82:939-43.
8. Spady WG. Outcome-Based Education: Critical Issues and Answers. Arlington, TX: American Association of School Administrators; 1994.
9. Hartel RW, Foegeding EA. Learning: Objectives, competencies, or outcomes? J Food Sci Educ 2004;3:69-70.
10. Rosner B. Fundamentals of Biostatistics. Boston, MA: Cengage Learning; 2015.
11. Rosner B. E102: Fundamentals of Biostatistics [Course Syllabus]. Cambridge, MA: Harvard University; 2016. Available from: https://canvas.harvard.edu/courses/8321/assignments/syllabus [Accessed March 10, 2020].
12. Gjertson DW. BIO STAT 100A: Introduction to Biostatistics [Course Syllabus]. Los Angeles, CA: University of California, Los Angeles; 2016. Available from: https://ph.ucla.edu/sites/default/files/attachments/BIOSTAT%20100A%20Syllabus.pdf [Accessed March 10, 2020].
13. Hsu P. Online EPID CPH576a: Biostatistics in Public Health. Tucson, AZ: University of Arizona; 2015. Available from: https://publichealth.arizona.edu/sites/publichealth.arizona.edu/files/576a_Spr15_Biostatistics%20in%20Pubic%20Health_Paul%20Hsu.pdf [Accessed March 10, 2020].
14. Programme Committee for Study Programmes in Biomedicine. 1BI043: Biostatistics [Course Syllabus]. Solnavägen, Sweden: Karolinska Institute; 2018. Available from: https://education.ki.se/course-syllabus/1BI043/22834 [Accessed March 10, 2020].
15. Chen SY, Feng Z, Yi X. A general introduction to adjustment for multiple comparisons. J Thorac Dis 2017;9:1725-9.
16. Akoglu H. User's guide to correlation coefficients. Turk J Emerg Med 2018;18:91-3.
17. Faraway JJ. Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models. New York: CRC Press; 2016.
18. Anderson TW. An Introduction to Multivariate Statistical Analysis. 3rd ed. Hoboken, NJ: Wiley-Interscience; 2003.
19. Kleinbaum DG, Klein M. Survival Analysis: A Self-learning Text. 3rd ed. New York: Springer; 2011.
20. Triola MM, Triola MF. Biostatistics for the Biological and Health Sciences. New York: Pearson; 2005.
21. Wayne WD, Cross CL. Biostatistics: A Foundation for Analysis in the Health Sciences. 11th ed. Hoboken, NJ: Wiley; 2018.