The Trend Toward Increased Use of Statistics in Published Orthodontic Articles

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An evaluation of the twofold increase in articles using statistics over the past ten years, finding most of the increase in the use of inferential statistics.

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A goal of all education is to develop in the learner the skills necessary for lifelong learning. This implies that the formal education of the orthodontist should provide the statistical tools necessary to critically evaluate published papers. As PROFFIT (1985) states, "the orthodontic practitioner is akin to the scientist who must continually evaluate new research findings."

A knowledge of statistics is certainly a prerequisite for evaluating many research papers. GIANELLY (1977) states that "Statistics describe and demonstrate the validity of new information which can improve the practice of orthodontics . . . . Statistical analysis is at least as important for the clinician as it is for the researcher, since he has to evaluate both clinical and research materials to improve his understanding and skills in treating patients."

In order to test the hypothesis that statistics is an everincreasing component of published orthodontic papers, the occurrence of statistical procedures used in papers published in the American Journal of Orthodontics were determined for the years 1975 and 1985. The findings underscore the importance of orthodontists being knowledgeable about statistical research design and analytical methods.

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— Method —

The frequency of occurrence of the various statistical procedures used in the original articles appearing in the American Journal of Orthodontics in the year 1975 are juxtaposed with those of 1985.

Statistical procedures are broadly divided into descriptive statistics (mean, standard deviation, range, percent, etc.) and inferential statistics (parametric, such as Student's t-test, ANOVA and Correlation/Regression, and nonparametric, such as chi-square). Because descriptive statistics are subsumed under inferential statistics, the two are not inherently mutually exclusive.

In order to separate the two in this study, only articles using descriptive statistics exclusively are listed in that category. In the inferential statistics category, ANOVA type statistics are further subdivided into factorial and nonfactorial. The frequency and percentage of articles requiring post hoc analyses were also determined.

Statistical Analysis

This analysis of statistical usage must also rely on statistical methods. A chi-square test ($P < 0.01$) and "Tests for differences between uncorrelated proportions" (GUILFORD 1965) ($P < 0.01$) are used to identify differences between the frequencies of occurrence of various statistical procedures used in Journal articles published in 1975 and 1985.

— Results —

72 original articles were published in the American Journal of Orthodontics in 1975, and 87 published in 1985. The percentage of articles using statistical procedures in 1985 (75.9%) is nearly twice the 43.1% used in 1975 (Table 1). In terms of the ratio of statistical to nonstatistical articles, we have seen an increase from 0.76:1 to 3.2:1.

The usage of descriptive statistics alone did not change significantly in those ten years. The change was primarily in the use of inferential statistics, which more than doubled, increasing from 23.7% in 1975 to 56.3% in 1985.

Use of Student's t-test increaed little, from 20.8% in 1975 to 28.7% in 1985.

Use of the ANOVA and Correlation/Regression type of inferential statistical procedures showed a significant increase (Table 2). Furthermore, of the 5 articles using ANOVA in 1975, only 1 article used factorial ANOVA, while factorial ANOVA was used in 17 of the 22 articles using ANOVA in 1985. This clearly indicates a trend toward increasing complex-

Table 1

Articles Using Statistics

	Descriptive		Inferential		None		
	N	%	N	%	N	%	Total
1975	14	19.4%	17	23.7%	41	56.9%	72
1985	17	19.6%	49	56.3%	21	24.1%	87

Chi-square (χ^2) = 21.029 $P < 0.01$

ity in the application of statistical procedures.

Post hoc analyses increased from 1.4% in 1975 to 18.5% in 1985.

Nonparametric statistical procedures, such as the chi-square test, have been used sparsely, only twice in 1975 and four times in 1985.

The descriptive statistic used most often in articles published in both years was the "mean" ($\bar{X}$). The inferential statistic most often used in both years was Student's t-test.

— Discussion —

This investigation supports the hypothesis that there has been an increase in the use and complexity of statistical procedures in published orthodontic papers over the past ten years. This is evident by the almost twofold increase in the percentage of articles using statistical procedures, the more than twofold increase in use of inferential statistics, and the increase in the use of the more complex type of inferential statistics such as ANOVA and factorial ANOVA between 1975 and 1985.

Parenthetically, the twofold increase in the use of statistical procedures was due almost entirely to the increase in the percentage of articles using inferential statistics. Consequently, today's orthodontist must be able to comprehend the intricacies of the many inferential statistics such as the Student's t-test, One-Way ANOVA, factorial ANOVA, and Correlation/Regression, as well as descriptive statistics, in order to understand and evaluate the the current orthodontic literature.

Descriptive statistics derive otherwise indiscernible information from the raw data. These include measures of central tendency and variability. Statistical parameters such as the mean ($\bar{X}$) and median are examples of measures of central tendency, while the range, variance, and standard deviation (S.D.) measure variability.

A mean ($\bar{X}$) is an arithmetic average. The standard deviation (S.D.) is a measure of the dispersion, or "scatter," of the data from the mean. Descriptive statistics are applied in practically all research studies, but they are of greatest value in surveys, epidemiological investigations, case study comparisons, and longitudinal studies.

Inferential procedures are used to test hypotheses. There are a number of inferential statistical tests, all having the same goal; to assist the investigator in reaching a conclusion whether or not the out-

Table 2

Usage of Inferential Statistics

Year	Student's t-test N	%	ANOVA N	%	Correlation/Regression N	%
1975	15	20.8%	5	6.9%	5	6.9%
1985	25	28.7%	22	25.2%	24	27.5%
Z-scores	1.1		*3.1		*3.4	

*Significant difference ($P<0.01$) as demonstrated by "Test for Differences Between Uncorrelated Proportions"

comes obtained are likely (probability) to be the result of chance.

However, chance can never be completely ruled out. Statistical tests simply indicate the *probability* that the results of a particular study may be due to chance. If that probability is 0.05 (5 chances out of 100) or less, the investigator can be far more confident in his results than if the probability of chance had been 0.50 (50%).

Parametric Procedures

Parametric statistical procedures should be limited to those studies in which the dependent variable(s) can be assumed to be normally distributed and the samples randomly selected.

The most commonly used parametric statistics used in published orthodontic articles are the Student's t-test, ANOVA, and the Correlation Coefficient (Pearson r).

Student's t-test is a method of testing the hypothesis of difference between means when only two groups (i.e., levels of the independent variable) are used. It answers the question whether or not there is a significant difference between two groups. Typically, it is used when the independent variable is manipulated at two levels, one level for the experimental group and a different level for the control group.

ANOVA is used to determine differences among many groups simultaneously, not just two. Factorial ANOVA addresses multiple independent variables.

While Student's t-test and ANOVA are used for cause-and-effect type research, the correlation coefficient (Pearson r) is used for testing the hypothesis of association. It indicates whether or not there is some relationship between two sets of measurements. If there is a significant relationship, the Pearson r also indicates the *strength* of the association. It is frequently used as an intermediate step in determining regression equations/lines that may then be used to make predictions.

The Pearson r should never be used in an attempt to isolate out a causal factor.

Nonparametric Procedures

When the conditions of random sampling and normal distribution are not met, nonparametric statistics are indicated.

The most often-used nonparametric statistical procedure is the Chi-square (χ^2) test. When certain assumptions about the data, such as homogeneity of variance, are violated, other nonparametric statistical procedures such as the Friedman ANOVA, Wilcoxon signed rank test, and the Kruskal-Wallis one-way ANOVA may be used.

The Chi-square (χ^2) test is used in both cause-and-effect and association types of research. Chi-square is used when research data are in the form of classified frequencies, such as the frequency of subjects falling into certain discrete categories.

Implications

Interestingly, most introductory statistics courses cover all of the above statistical procedures except the factorial ANOVA. However, there was a heavy usage of factorial ANOVA in 1985.

Perhaps a greater knowledge of research principles and statistics would enable practitioners to more critically evaluate research findings, and perhaps be less likely to accept some scientifically unsound notions of self-proclaimed experts heard on today's lecture circuits.

Assuming that many practitioners lack a fundamental knowledge and understanding of the statistics being used in

current research, there is a need to address these subjects in continuing education programs as well as dental school curricula at both pre- and postdoctoral levels.

In addition to a course in research design and statistics, directors of nondegree postdoctoral certificate programs that do not require research projects should consider the implementation of such projects. How better to learn statistics than to apply them to one's very own research, provided that the application is done by the researcher and not delegated to another department with results taken on uninformed faith.

— Summary and Conclusions —

- There has been an almost twofold increase in the use of statistical procedures in the articles appearing in the American Journal of Orthodontics from 1975 to 1985.
- That increase is due primarily to the increase in articles using inferential statistics.
- This trend toward increased use and complexity of statistical procedures in published orthodontic articles suggests a need for orthodontists to be fully familiar with statistical procedures.

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