Determining the Statistical Knowledge of Pharmacy Practitioners: A Survey and Review of the Literature[1]

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Increasing complexity of medical studies and statistics make it important for pharmacists to be able to evaluate the appropriateness of statistical tests used in the literature and assess if reasonable conclusions were drawn. To determine if pharmacists are able to perform this evaluation, a two-part survey was designed that asked demographic and 10 multiple choice statistical questions. Of the 2500 surveys mailed, 707 (28.3 percent) contained usable responses. The average score on the statistical portion was 2.80 out of 10 (SD=2.0). Part of the reason for this low average was that 57.5 percent of statistical questions were answered "E" -1 don't know. Most commonly, pharmacists appeared to understand a crossover study design (77.7 percent correct), characteristics of statistical tests (62.5 percent), and statistical versus clinical significance (50.8 percent). Pharmacists had difficulty identifying other common statistical terms. From this study, pharmacists appear to lack the necessary skills to evaluate the statistical section of medical studies.

INTRODUCTION

Pharmacists must be adept at locating and evaluating drug information in order to be effective providers of pharmaceutical care. A vast array of abstracted resources assist in this endeavor, sometimes reducing the need to directly evaluate primary literature. Nevertheless, there are times when secondary and/or tertiary references do not provide sufficient information, and a pharmacist has no choice but to confront a primary journal article. Most health professionals feel comfortable evaluating some of the basic components of a research article (*i.e.*, abstract, introduction, methods, results, conclusion/discussion, and references). A series of papers in *Annals of Emergency Medicine* discusses how to evaluate each part of an article and, Gehlbach, Riegelman and Hirsch, and Smith, Norton and Ferrill have written textbooks on the subject(l-6). These resources, and many other references, provide a sound basis for evaluating the quality of a research article from the standpoint of purpose, rationale, and conclusion. Hence, it is not difficult for a knowledgeable health professional to determine whether or not the purpose, methodology, and conclusions are aligned with the scientific methodology. But, how well can pharmacists assess the appropriateness of statistical analysis and relate statistical analysis to the corresponding conclusions drawn? These are the points at which the comfort level of many pharmacists may drop off the scale - into the terrifying world of statistics. There are many statistical textbooks and articles available that can aid the journal reader in interpreting the validity of statistics(7-9). However, these references are often too detailed for individuals to quickly grasps these statistical concepts and apply them to the statistical sections of articles.

To make a difficult situation worse, almost as if designed to decrease the journal reader's level of comfort further, the methods section of many journal articles, including the description of the statistical analysis, is often at least one font size smaller than the rest of the article. This may lead the reader to mistakenly conclude the information presented in the smaller font is of lesser importance.

Many pharmacists may want to assume that the statistical tests chosen and used by authors are correct, and that the conclusions based on those statistical tests were also valid. These assumptions may be guided by the readers belief that the journal has an adequate statistical review process. Unfortunately, these may not be accurate assumptions(10,11). Goodman and colleagues surveyed the statistical review policies of 114 "high-impact" medical journals between 1993 and 1995. It was determined that approximately 33 percent of surveyed journals had a policy that assured a statistical review of all applicable manuscripts. The authors of this survey concluded that, excluding the largest circulation journals (> 25,000), the likelihood of a research article receiving a formal statistical review is fairly low(12). One "high-impact" journal, *The Lancet*, incorporates a statistical review process for all submitted papers. In a 1992 review, approximately one-half of the articles initially submitted to *The Lancet* had inadequate description of methods and results and major statistical errors. The authors concluded that statistical review of articles by journals is necessary since many have significant errors when initially submitted. This statistical review process will help to ensure that conclusions are justified by study design and statistical analysis(13). In 1990, similar results were also published for the *British Medical Journal*. Only 11 percent of submitted articles were initially considered statistically acceptable. This percentage increased to 84 percent after review and revision(14).

Several articles have examined the appropriateness of the use of statistics in published original research articles. Examination of primary articles from selected medical and

[1]This project was supported, in part, by a grant from Syntex Laboratories, Inc.

pharmacy journals for the 21 years between 1975 and 1996 revealed the use of inappropriate or incomplete descriptions of statistics between 22 to 100 percent of the time. Some of the reviewed articles were considered to have serious statistical flaws(15-26). Based on these studies and the problems they revealed, it is apparent that appropriate independent evaluation by each individual reader of the statistical section of an article is essential in assessing the validity of the entire article. If the wrong statistical tests were used, the results of the study are difficult, if not impossible, to interpret. Therefore, it is necessary to understand the basic assumptions for the use of statistics to determine if the appropriate statistical tests were chosen, and what weight should be given to the statistics in the results section. In contrast, if inappropriate tests were chosen, the reader must determine what, if any, useful information can be concluded from the study.

There has been a trend in the medical literature toward an increased use of detailed statistical analysis(16,24,27-31). When the journal, *Arthritis and Rheumatism*, was examined between 1967-1968 and again in 1982, the percentage of articles that utilized statistics had increased from 50 to 62 percent(28). Similar results were noted for the *Annals of Emergency Medicine*. The number of articles that used statistics went from three articles with descriptive statistics in 1972 to 62 articles with inferential statistics in 1982(31). Wang and Zhang reported that the proportion of Chinese medical journals utilizing statistics increased from 40 percent in 1985 to 60 percent in 1995(24). Another study compared the use of descriptive statistics (*e.g.*, mean, SD, SE) in articles published in the *New England Journal of Medicine* during 1990 to those published between 1978 and 1979. The number of articles that used primarily descriptive, rather than inferential statistics, decreased from 27 percent in 1978 -1979 to 11 percent in 1990(28).

In follow-up to these articles, a literature search was conducted, but no studies were found that were designed to determine if pharmacists and/or pharmacy students have a working knowledge of statistics. However, several articles were located that were designed to determine the statistical knowledge of physicians(32-34).

A 1987 multiple choice survey with nine statistical questions (*e.g.*, *P* values, mean, SD, SE) was administered to a random sample of 148 Danish doctors, and was also given to 97 junior hospital doctors (nonrandom sample) enrolled in a biostatistics course. The median scores were 2.4 out of nine for the random sample and 4.0 out of nine for the nonrandom sample. The authors stated that doctors in Denmark may not be sufficiently trained to evaluate medical literature(32). Another study published in 1980 sent a 10-item survey to 229 internists and medical house staff at a teaching hospital to determine physicians' knowledge of statistics and epidemiology. The questions were clinically oriented based on problems found in six top medical journals (*e.g.*, *NEJM*, *BMJ*). Of the 141 useable responses, the mean score was 7.4 (SD=1.6) out to 10. When statistical questions were averaged separately, respondents' mean scores decreased to 2.6 (SD=1.0) out of 10. The authors of this study noted that practicing physicians had a significantly lower average score (P<0.01) when compared to academic-based physicians on biostatistic related questions. In addition, those who had prior training in statistics had a significantly higher average (P<0.01) than those who did not(33). From these studies, it appears that physicians do not have the skills necessary to adequately analyze the statistical section of medical studies.

Overall, it appears that there continues to be a high number of published articles that have inappropriate statistical analysis. The statistical review process of many journals are inadequate, and many healthcare providers may not be able to independently interpret results. Studies have also shown that journals are using more detailed and complicated statistical analysis. Although several studies have examined the statistical knowledge of physicians, none could be located that examined the statistical knowledge of pharmacists. Therefore, the purpose of this study was to determine, via a multiple choice questionnaire, if pharmacists have the basic statistical knowledge believed to be required to evaluate medical and pharmacy studies.

METHODS

A survey was designed which asked 10 multiple choice questions concerning the most common statistical tests and terms used in the literature (*i.e.*, student's *t*-test, chi-square, analysis of variance, confidence intervals and *P* values) and other information (*i.e.*, null hypothesis, power, assumptions underlying a statistical technique, characteristics of a statistical test, and clinical versus statistical significance) required to effectively read and analyze the statistical section of journal articles(11,21,22,24,27-31,33,35-48) (see Appendix).

A 1994 pilot survey intended to detect problem questions was completed by 10 pharmacists prior to mailing the official survey. The survey was modified to incorporate suggestions, and a mailing list of 2500 randomly selected pharmacists and students was obtained from the reader's list of *U.S. Pharmacist*. To be conservative, a total of 2,500 surveys were mailed. Assuming a 30 percent response rate, a total of 750 surveys would be available for data analysis, which was expected to provide adequate power for comparisons. Along with the survey, pharmacists received a letter stating that they had been chosen from a random sample of pharmacists and pharmacy students to participate in a brief survey to determine the level of understanding pharmacists and pharmacy students have of statistical principles required to evaluate the methods and results sections of research articles.

The survey was designed to take less than five minutes to complete. Each of the survey questions required only a check mark in the selected answer box. The pharmacists were instructed to mark only one answer and that it was extremely important that they answer each question as best as they could, but that they should not "guess." A response of "I don't know" was included as a selection. In addition, the pharmacists were asked to not confer with a colleague or consult a reference to determine the correct answers. Lastly, the respondents were assured that their responses would be kept completely confidential and that only combined results would be reported. The survey and letter were mailed twice, four weeks apart, followed by a postcard reminder.

Percentages and mean ± SD were used to report descriptive statistics. Regression analysis was used to determine if statistical knowledge varied as a function of demographic characteristics (*e.g.*, years since graduation, practice site, education level). If significant differences were found, a post hoc t-test was performed. Level of significance was set at $P < 0.05$.

RESULTS

Of the 2,500 surveys mailed, 729 (29.2 percent) were returned, of which 707 (28.3 percent) contained useable responses. The

Table I. Percentage of respondents

Question #	Question description	Percent correct (N=707)	Percent answering question (n)	Percent answering question incorrectly
4	Assumptions of statistical technique	77.7	82.2 (581)	5.5
2	Characteristics of a statistical test	62.5	68.5 (484)	8.7
6	Statistical versus clinical significance	50.8	75.2 (532)	32.5
8	Confidence intervals	22.9	33.4 (236)	31.4
1	Null hypothesis	18.2	32.5 (230)	43.9
9	P values	13.0	43.3 (306)	69.9
3	Student's *t* test	10.0	21.2 (150)	52.7
7	Power	17.8	25.0 (177)	29.4
5	Chi square	5.1	18.2 (129)	72.1
10	ANOVA	2.0	9.6 (68)	79.4

Table II. Demographic data from the 707 useable surveys

Pharmacy Education and Training		**Years Since Graduation**	
BS only	83.3% (n=589)	0-5	12.9% (n=91)
PharmD only	6.8% (n=48)	6-10	13.3% (n=94)
Other or unknown	9.9% (n=70)	11-15	18.7%(n=132)
		16-20	19.4% (n=137)
		>21	34.2% (n=242)
		Unknown	1.6% (n=11)
Pharmacy Practice Site[a]		**Primary Position**[a]	
Community	68.3% (n=483)	Manager	47.7% (n=337)
Hospital	20.8% (n=147)	Staff	41.4% (n=293)
Home/LT care	3.4% (n=24)	Clinical	5.6% (n=40)
Not practicing	1.4% (n=10)	Consultant	2.5% (n=18)
Other	6.7% (n=47)	Other	2.3% (n=16)
Unknown	0.7% (n=5)	Unknown	1.7% (n=12)

[a]Numbers do not add up to 100 percent because some individuals chose multiple items.

number of questions answered correctly ranged from 0 to 10 with an average of 2.80 (SD=2.0). Table I shows the percentage of respondents who answered each question correctly. The majority of respondents knew that: (*i*) a crossover design is one in which participants are exposed to both the control and experimental medication (Question 4); (*ii*) data type, study design, and number of planned comparisons must all be taken into consideration when choosing a statistical test (Question 2); and (*iii*) statistical significance is not the same as clinical significance (Question 6). All of the remaining questions were answered correctly by fewer than 25 percent of the respondents.

Out of the total of 7,070 questions, (10 per respondent), 4,065 (57.5 percent) were answered "I don't know." Table I shows the number and percentage of respondents who answered each question. Only Questions 2, 4, and 6 were answered by the majority of respondents. The last column in Table I shows the percentage of respondents who answered each question incorrectly, with "I don't know" and missing data excluded. The figures in this column demonstrate that, even when instructed not to guess, a substantial proportion of respondents provided incorrect answers in response to most of the questions asked. Overall, 31.6 percent of the items answered were answered incorrectly.

To determine if the number of questions answered correctly varied as a function of practice site (*i.e.*, community pharmacy versus other), education (*i.e.*, bachelor's degree only versus other), or number of years since last degree was attained, a multiple regression analysis was performed (see Table II for descriptive characteristics). Number of questions answered correctly was regressed on the three practice-related variables listed above. The overall model was significant, $F(3,677)=54.39$, ($P<0.0001$) and explained 19.4 percent of the variance in the number of questions answered correctly. Each of the predictor variables also was significant. Community pharmacists answered an average of 2.46 (SD=1.76) questions correctly compared to 3.56 (SD=2.31) for pharmacists practicing in other sites ($t=6.19$, $P<0.0001$). Pharmacists with training beyond a bachelor's degree answered an average of 4.09 (SD=2.48) questions correctly compared to 2.55 (SD=1.80) for those with only a bachelor's degree ($t=634$, $P < 0.0001$). Finally, the correlation between time since one's last degree and number of correct answers was -0.34 ($P < 0.0001$). The number of questions answered correctly ranged from 3.91 (SD=2.17) by those who had received their most recent degree within the past five years and 2.03 (SD=1.68) by those who had received their most recent degree over 20 years previously.

Exploratory analyses revealed that the number of questions answered was associated with practice site ($t=6.22$, $P<0.0001$), education ($t=6.41$, $P<0.0001$), and number of years since one's last degree ($r = -0.37$). Community pharmacists, respondents with only a bachelor's degree, and those who had been out of training for a longer period of time answered fewer questions than other respondents. To adjust for this potential confounding factor, a new variable was created by subtracting the number of questions a respondent answered incorrectly from the number of questions answered correctly. The regression analysis described above was then repeated with this new variable used as the dependent variable. As before, the overall model was statistically significant, F(3, 677)=13.89, (P<0.0001), as was each predictor variable.

Finally, an exploratory analysis was performed to determine if respondents with only a bachelor's degree (n=577) scored lower than respondents with only a PharmD (n=47). A Mest revealed that respondents with a PharmD and no additional training answered more questions correctly, x's = 3.98 and 2.55, respectively, (P<0.001). This difference remained significant when incorrect responses were subtracted from correct responses.

DISCUSSION

The findings of this randomized survey of pharmacists suggest that pharmacists do not have the necessary background in statistics to be able to evaluate the results of many medical and pharmacy research articles. Although several factors such as community practice site, BS degree only, and greater than 20 years since receiving their last degree were contributing factors, overall, the majority of pharmacists "failed" the statistical section of the survey. This investigation was conducted because no such study of the statistical knowledge of pharmacists could be located in the literature. However, an article in the *American Journal of Pharmaceutical Education* presented the statistical background that pharmacists need to efficiently and effectively read pharmacy journals(35). Unfortunately, information was not provided as to whether students or pharmacists receive this background in school or postgraduate training, and whether they are capable of effectively evaluating scientific literature. In 1985, Hokanson, *et al*. surveyed schools of pharmacy to determine if statistics were included in the curriculum, and if so, which statistical methods were being taught. Of the 65 schools that responded, 44 (67.6 percent) indicated that their school required some training in statistical methodology prior to graduation. In the same study, the authors also surveyed eight pharmacy journals, but no medical journals, to determine their frequency of use of statistical methods. The authors concluded that pharmacy journals are increasingly using sophisticated statistics, and in general, schools of pharmacy are not providing students with adequate information to analyze the statistics that appear in pharmacy journals(49).

In 1993, Mullins *et al*. surveyed 66 schools of pharmacy and determined that 41 schools (62 percent) teach statistics as part of their drug information courses(50). Additionally, Juergens et al. published an article in 1992 that determined the level of pharmacy school training in the principles of pharmacoeconomics. A section in Juergen's article examined the types of statistics taught. In required courses, the percentage of statistical techniques taught ranged from 2.2 percent for multiple comparison procedures to 64.7 percent for descriptive statistics. Unfortunately, only 57.4 percent of schools had intentions to increase their coverage of statistics during the following three years(51). This lack of emphasis on statistical evaluation appears to continue to be an issue in both medical and pharmacy education, although the issue was mentioned as early as 1977 in the pharmacy literature in an editorial in the *American Journal of Pharmaceutical Education*(49,51-56).

There were several limitations of this study. It is not known whether achieving high scores on this multiple choice statistical survey would adequately predict the ability of a pharmacist to critically analyze the statistical section of an article and apply this information to the rest of the study. Also, the survey did not ask about either prior training in biostatistics or journal reading habits. As mentioned, the mailing list was randomly selected from the mailing list of *U.S. Pharmacist*. Selecting this sample may have had an impact on the population surveyed and possibly the results. In addition, the surveys were not coded, and pharmacists were not asked to provide other information beyond basic demographics. The two mailings and postcards were sent to all 2,500 pharmacists and students randomly selected from the *U.S. Pharmacist* list. It is possible that some individuals surveyed responded to more than one of the mailings, although they were asked not to do so. Most respondents (83.3 percent) had only a BS degree. However, most colleges/schools are converting to PharmD programs, therefore the statistical training that today's graduates receive may better prepare them for journal analysis. As stated in the results, the pharmacists with a PharmD degree scored significantly higher than those with only a BS degree. In addition, 53.6 percent of the respondents graduated 16 or more years ago and may not have had formal training in statistical analysis. Wording of some of the test questions, particularly Question 7 (pertaining to power) was another potential limitation. Adjustments were made in the final analysis of the questions to include more than one correct answer to adjust for this confounding factor. Lastly, pharmacists who had little knowledge, or no interest in statistics may have been less likely to complete and return the survey. This could potentially falsely elevate the mean scores. In addition, responders may have conferred with a colleague or used a reference book or other sources that may have also falsely elevated the scores.

CONCLUSIONS

Based on the results of this survey as demonstrated by an average score on the survey of only 2.8 (SD=2.0) out of 10, and related literature, many pharmacists do not appear to have a working knowledge of basic statistical terms, including the appropriate use of different statistical tests. Moreover, although pharmacists were asked not to guess, 31.6 percent of responses were incorrect, indicating that pharmacists who have some knowledge of statistics tend to overestimate that knowledge.

From our data, it appears that pharmacists do not have adequate basic knowledge of statistics to adequately analyze the appropriateness of the use of statistics in the methods and results sections of research articles. With the increasing use of statistics in medical and pharmacy journals and the apparent lack of understanding of statistical concepts by pharmacy practitioners, colleges/schools of pharmacy should determine if statistical application is being covered sufficiently in their respective core curricula. Draugalis and colleagues have written two articles describing a series of courses that provide pharmacy students with the biostatistic skills that will allow them to interpret and evaluate the medical literature. A method to evaluate student comprehension is also provided(57,58). Continuing education courses on statistical literature evaluation should be offered to allow current practitioners to develop such skills to efficiently and effectively analyze all sections of journal articles. In addition, journals should continue to improve their policies on editing and reporting of statistics in articles by requiring authors to describe and explain their statistical section in detail and articulate in the discussion and conclusion sections how the statistics affect their results. This will help to ensure that the limitations of each study are openly addressed and the stated conclusion will provide readers with a legitimate assessment of the study's potential clinical application(12,59).

Acknowledgement. The authors would like to thank Thomas N. Kakuda, PharmD, Infectious Diseases Fellow, Department of Experimental and Clinical Pharmacology, School of

Pharmacy, University of Minnesota, for his valuable assistance.

Am. J. Pharm. Educ., **63,** 371-376(1999); received 6/7/99, accepted 8/13/99.

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APPENDIX I. SURVEY

Section I: Statistical Questions

1. Characteristics of the null hypothesis include:
   □a Is a statement of no difference between or among groups.
   □b The goal of every study is to reject the null hypothesis.
   □c If the null hypothesis is accepted, there is a difference.
   □d If the null hypothesis is rejected, there is no difference.
   □e I don't know
2. Which of the following characteristics must be considered when choosing the correct statistical test?
   □a Data type (*e.g.*, interval vs. ordinal)
   □b Study design
   □c Number of comparisons
   □d All of the above
   □e I don't know
3. All of the following are true concerning use of Student's *t* test EXCEPT:
   □a Used with interval or ratio data.
   □b Baseline characteristics of patients should be similar.
   □c Requires a normal distribution.
   □d Used to compare 3 or more groups.
   □e I don't know
4. A study examined 30 patients with pain, randomized to receive either aspirin or ibuprofen and then switched to the other treatment. The type of study design is:
   □a Retrospective
   □b Placebo-controlled
   □c Crossover
   □d Parallel
   □e I don't know
5. Which of the following types of data are most appropriately analyzed using the Chi Square test?
   □a Gender
   □b Likert Scale (*i.e.*, strongly agree, agree, no opinion, disagree, strongly disagree)
   □c Blood pressure readings
   □d Height
   □e I don't know
6. If statistical significance has been demonstrated, the reader can be assured of the clinical significance of the findings of a study.
   □a True
   □b False
   □c I don't know
7. "Power" in a study describes:
   □a The strength of the statistical test used (Type I and Type II errors).
   □b The number of subjects required to help ensure statistical errors do not occur.
   □c The relevance of the subject to medicine.
   □d All of the above
   □e I don't know
8. Which of the following are characteristics of confidence intervals:
   □a Confidence intervals provide an estimate of the range where the true mean value in the affected population is likely to reside.
   □b Are abbreviated as CI or C.I.
   □c The most commonly used confidence interval is 95 percent.
   □d All of the above
   □e I don't know (over F)
9. In studies where the level of significance is not stated, a P<0.05 reported with the data implies that:
   □a There is a <5 percent probability of stating that there is a difference when one does not exist.
   □b A statistically significant difference was found between groups tested.
   □c A clinically significant difference was found based on the p value.
   □d A and B
   □e I don't know
10. For multiple comparisons, all of the following assumptions are true concerning use of the ANOVA test alone EXCEPT:
   □a Used with interval or ratio data.
   □b Determines where the significant difference between groups exists.
   □c Baseline patient characteristics between groups should be similar.
   □d Requires use of a post hoc test (*e.g.* Scheffé) if a significant difference is found.
   □e I don't know

Section II: Personal Demographics

11. Pharmacy Education and training: (check all that apply)
   □ BS □ BCPS □ Pharm.D. □ Residency
   □ Ph.D. □ Other______________
12. Years since latest degree:
   □ 0-5 □ 6-10 □ 11-15 □ 16-20 □ >21
13. Primary Practice Site (check one)
   □ Hospital pharmacy
   □ University faculty
   □ Community pharmacy
   □ Home-health care or long term care
   □ No longer in practice
   □ Other (please specify):_________________________
14. Primary Pharmacy Position (check one)
   □ Administrator or Director or Assistant Director or Manager
   □ Clinical pharmacist
   □ Professor
   □ Staff
   □ Consultant pharmacist
   □ Other including students (please specify):
15. Would you like to receive the results of this survey when they are available? If you answer YES, please include a business card or name and mailing address.
   □ Yes □ No

Answers to survey: 1. A; 2. D; 3. D; 4. C; 5. A; 6. B; 7. A or B; 8. D; 9. D; 10. B.