TRAINING CHIROPRACTORS FOR CAREERS IN CLINICAL RESEARCH

Cynthia R. Long
Palmer Center for Chiropractic Research, United States
long_c@palmer.edu

A two-year clinical research curriculum offered in a graduate program at a U.S. chiropractic college was implemented in Fall 2003 and enrolls three to six chiropractors per year. The curriculum includes ten credit hours of required courses in biostatistics. Introductory courses in biostatistical thinking and reasoning and data management are offered the first term, followed by basic statistical methods, statistical graphics, and advanced topics over the next three terms. Trainees typically have little previous exposure to statistics, so program objectives move from developing critical appraisal skills to writing strong data-related sections in grant applications. As graduates will likely pursue careers at chiropractic colleges with little or no research infrastructure, nor necessarily a research culture, it is paramount they develop a strong foundation in research methods and become proficient users of statistical tools to succeed.

INTRODUCTION

Inadequate training in research methods for health care practitioners has been identified as a barrier to the development of quality patient-oriented research. This is particularly true for complementary and alternative medicine (CAM) practitioners such as chiropractors. Although chiropractors are the largest group of licensed CAM providers in the U.S. and have the most well-established educational program of all the CAM professions, research training does not play a significant role in that program (Coulter, Adams and Sandefur, 1997). Only 6% of chiropractic college faculty are engaged in research and a minority of those are involved in clinical research (Marchiori, Meeker and Hawk, 1998). Furthermore, although chiropractic faculty conducting basic science research have graduate training in their discipline, few conducting clinical research have any formal training in research methods.

Biostatistics education must play a central role in training health care practitioners to conduct clinical research. Successful methods of biostatistics instruction for medical physicians in academic settings have been presented by several authors. Ambrosius and Manatunga (2002) describe introductory short courses designed to teach biostatistics to physicians to facilitate future collaboration with biostatisticians. Deutsch (2002) describes seminars focused on teaching physicians how to interpret research articles and to collaborate with biostatisticians, as well as to design studies and analyze their own data. However, methods of statistical instruction for other health care professions, including CAM practitioners, have received little attention.

Chiropractic colleges in the U.S. have little research infrastructure and on-campus statistical support is rarely available. Therefore, clinician scientists at chiropractic colleges need to be statistically competent, be able to analyze their own data, and recognize when to seek guidance from biostatisticians. In an effort to educate chiropractors to become effective clinician scientists, we developed a 36 credit hour clinical research curriculum at a chiropractic college that culminates in a Master’s of Science in Clinical Research (Long, Hawk and Meeker, 2002). This paper describes the biostatistics coursework in the program.

BACKGROUND

My experiences providing statistical support to chiropractors and teaching biostatistics to chiropractors in a graduate anatomy program indicated that most academic chiropractors have little understanding of statistical concepts and are unable to use statistics as a research tool. Chiropractors entering this clinical research program are no different. They have typically completed a formula-based statistics course as an undergraduate and a course in reading the literature or basic research methods in their chiropractic curriculum. Content in the latter is inconsistent across colleges and no better received than similar courses in most medical schools.

From 1995-2001, I taught an annual three credit hour course in biostatistics to graduate students in anatomy; over half of the students were chiropractors and most others had a health-related background. The course was developed to center around the evaluation of journal articles and the analysis of real data. The data came from research projects conducted at my institution and the journal articles were always topically related to chiropractic.

Class sizes ranged from 2-10 students allowing for much interaction. Challenges in teaching this course included: computer-illiterate students; too much material to cover; no opportunity to train in data management; and the difficulty in integrating design and statistical thinking concepts with the required material. In developing the coursework for the new program I reflected on my experience in teaching this course as well as examining many programs focused on training clinician scientists. Five additional credit hours of more advanced biostatistics topics and two prerequisite courses to the original biostatistics course were proposed.

I looked to the reform movements in statistics education over the past 10-15 years in developing these new courses. Although much of this effort has been focused on the introductory course in undergraduate programs, the reforms were consistent with my own teaching strategies. The reforms were captured in the recent recommendations of the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Reports (2005) which include:

- emphasizing statistical literacy and statistical thinking;
- using real data;
- using technology to analyze data;
- using assessments to improve and evaluate student learning;
- focusing on conceptual understanding; and
- using technology to promote conceptual understanding.

The first four were central to the development of the original biostatistics course. The GAISE recommendations shaped the new prerequisite courses, the modifications to the original biostatistics course, and the themes carried through the development of the advanced biostatistics courses. The overall objective of the biostatistics coursework in the clinical research curriculum was to foster biostatistical thinking and reasoning in students as they became proficient users of statistical tools.

CURRICULUM

The clinical research program is full-time over two years in six consecutive 15-week trimesters. The program commenced in the Fall of 2003 and matriculates 3-6 research fellows per year. Table 1 presents the format and topics covered over the 10 credit hours of biostatistics courses in the program. Consistent objectives through all courses included:

- developing a vocabulary of statistical terminology;
- framing research questions;
- identifying outcome and explanatory variables;
- characterizing appropriate data analysis approaches;
- performing data analysis;
- interpreting results in the context of research questions; and
- writing research reports.

Standard reporting guidelines, refined from the recommendations in Long, Nick and Kao (2004), were emphasized in writing and presenting research results.

Courses

A course in biostatistical thinking and reasoning was developed as a prerequisite to the biostatistics methods sequence. The course objectives were guided by the work of Chance (2002), Garfield (2002) and Rumsey (2002). The focus was to promote the basic understanding of statistical methods in the scientific research process through evaluating research articles topically related to chiropractic. A second prerequisite course in statistical computing taught students how to use statistical software with a point and click interface to manage data.

This allowed room in the original biostatistical methods course to integrate the use of applets and other Web resources into lectures to promote a conceptual understanding of the material. This began with the introduction of probability and sampling distributions and continued as part of the introduction of each new topic. Topics in this course covered parametric and rankbased methods for estimation and testing in experimental study designs and associated sample size and power considerations.

A course in statistical graphics was also developed. Over half of this course was dedicated to introducing students to exploratory data analysis techniques. Students were taught how to produce graphics such as boxplots, dotplots, normal probability plots and residual plots in *SPSS* and how to use them to assess methodological assumptions and identify outliers. Scatterplots and smoother functions were also covered. The remainder of the course developed best practices for producing graphics in presentations and manuscripts.

The three credit hours of advanced statistical topics were split between two trimesters to accommodate my teaching schedule. In Biostatistics IIa, correlation and simple linear regression methods were taught, including the use of the exploratory data analysis techniques previously introduced and influence analysis. Biostatistics IIb extended this to modeling with multiple linear and logistic regression. The course ended with topics including analysis of repeated measures data and methods for dealing with missing values.

Table 1: Biostatistics courses

Course	Credit hours	Trimester offered	Format	Topics
Biostatistical Thinking and Reasoning	1	1	1×/week for 10 weeks	Variability, types of error, strategies for minimizing error; study design, types of variables, basics of descriptive and inferential statistics
Statistical Computing and Data Management	1	1	1×/week for 10 weeks	Using *SPSS*, key-entering data, data quality control, setting data attributes, creating new variables, importing and merging datasets, using syntax, data cleaning and storage guidelines
Biostatistical Methods I	3	2	2×/week for 15 weeks	Descriptive statistics, sampling distributions, estimation and testing using standard 1-, 2- and multi-sample statistical methods
Statistical Graphics	2	3	1×/week for 12 weeks	Exploratory data analysis, graphics for publication and presentation
Biostatistical Methods IIa	1	3	1×/week for 8 weeks	Correlation, linear regression, ANCOVA
Biostatistical Methods IIb	2	4	2×/week for 15 weeks	Linear regression, logistic regression, multi-way ANOVA, repeated measures, missing data

Use of Real Data

Real data from a wide variety of study designs were used in all courses. Most of the data came from research projects conducted at my institution; however, in the last two years clinical research colleagues at other institutions made a few large datasets available. For each course, several datasets were chosen to demonstrate data analysis techniques in class and several others for use in assessments. Select datasets were used across all courses. An *SPSS* tutorial was created based on each class demonstration. All datasets and *SPSS* tutorials were posted and could be downloaded from the course Web site.

Assessments

The biostatistical thinking course was pass/fail; all others were letter graded from A-F. Course assessments included homework assignments, exams and projects. All assessments were take-home format allowing at least one week for completion. Each assessment was intended to be outcome-based in line with the learning objectives of the corresponding lectures. Students were encouraged to work together, but each handed in their unique written product. Detailed instructor feedback was given on all assessments. Students also had the opportunity to revise and resubmit homework assignments based on the feedback.

Homework assignments for the biostatistical thinking course were article critiques focused on the topics being covered in a given week. Homework assignments for the biostatistical methods courses involved going step by step through each data analysis technique. However, exams typically involved two separate datasets and research questions where a student identified the primary outcome and explanatory variables, chose an appropriate statistical method, conducted the data analysis, interpreted the results, and wrote a research report. Exams also included article critiques. In the last biostatistical methods course, in addition to homework assignments, there were two projects in which each student was provided a dataset and research questions that differed from others. Items handed in included a copy of the data analysis plan, a copy of the statistical output and its accompanying syntax, a log of all of the steps taken and decisions made, and the final research report.

Example

The two projects assigned as part of the last course in this biostatistics sequence in the 2005-2006 academic year involved the same dataset. These data came from an observational study of nearly 2000 acute and chronic low-back pain patients who sought care from a chiropractor in one U.S. state in the late 1990s. The dataset contained 16 baseline demographic and clinical history variables and two primary outcome variables assessing low-back pain and pain-related function over a four year period. Each student received an *SPSS* dataset with a different random sample of approximately 20% of the original dataset, the outcome variables for a unique endpoint (e.g., six months, two years) and all of the baseline variables.

Both projects had the overall objective of building multiple regression models to explain each of the two primary outcome variables by considering all of the baseline variables as possible candidates. The goal of Project 1 was to model the continuous outcome variables, while that of Project 2 was to model dichotomous outcome variables based on clinically relevant cut points. Students had four weeks to complete Project 1 and 2.5 weeks to complete Project 2. The instructions provided for each project were as follows:

- Get to know your data: compute descriptive statistics for all variables in the dataset;
- Write a detailed data analysis plan;
- Get to know your data: perform exploratory data analysis (EDA). Evaluate the EDA and provide your commentary in the *SPSS* output or a separate document;
- Conduct your model building—follow your plan, which should include the following:
    - use an all possible regressions modeling approach
    - verify model assumptions, or take appropriate action so that model assumptions are valid
    - consider the possible need to include terms for interactions
    - consider the possible need to include higher order terms
    - evaluate models for influential observations
    - assess multicollinearity;
- Choose your final models, support your choice and report them according to recommended guidelines;
- Write the research report: make sure to include a description of your model building methods, refer to your table(s) when reporting your results, and interpret your final models.

Students were asked to attach electronic versions of the above to the e-mail submission of each completed project.

This example illustrates a process where students had to integrate information learned over the biostatistics course sequence to analyze their unique dataset. The final product was a research report similar to what would be prepared for a draft of a manuscript. The students fully understood that they would each have different results, but appreciated having the same data structure to allow them to discuss with each other different approaches and problems encountered.

They also felt using the same dataset for both projects facilitated a better understanding of the overall process. Four of the five students in this course demonstrated data analysis proficiency in Project 1 and all five did so in Project 2. Although this is only representative of current ability in a supportive environment, the experience should provide a data analysis approach for students to follow as they pursue research careers.

DISCUSSION

Biostatistics education plays a central role in this program to train chiropractors as clinician scientists. Successful methods for training this practitioner population have not been previously identified. The second class of research fellows will soon complete the sequence of biostatistics courses described in this paper. Although the example illustrated data analysis competence in one cohort of students, it is difficult at this early time in the program to determine if the biostatistics instruction was successful. Track records of graduates' peer-reviewed publications and research funding will be the true test of our success in training chiropractors for careers in clinical research.

The addition of the first two prerequisite courses in the curriculum helped overcome the challenges encountered in the original biostatistics course (Long, 2004). By providing consistent objectives across courses, promoting conceptual understanding of biostatistics, using real data topically related to chiropractic, and using outcome-based assessments, we have increased our likelihood of producing statistically competent clinician scientists.

Student evaluations of the courses have generally been positive. The focus on writing research reports using standard guidelines has been frustrating for some students. However, all students have commented on the usefulness of that practice as they move through the program. Thus far, students have been well-prepared in writing manuscripts based on their mentored research experiences. They have also found the training especially useful in preparing data management, data analysis and sample size sections in a subsequent course on grant writing.

This sequence of courses is not necessarily appropriate for trainees in traditional research environments. They may have a stronger statistics background, be unable to fully immerse in a two year program, and have some statistical support available. However, graduates of this program will likely pursue careers at chiropractic colleges with little or no research infrastructure, nor necessarily even a research culture. Therefore, it is paramount they develop a strong foundation in research methods and become proficient users of statistical tools to succeed in these environments. Fitting all of these courses in the framework recommended for the first undergraduate course (GAISE, 2005) may be an effective approach to training chiropractors and other practitioners in environments without research infrastructure as clinician scientists.

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