

# Teaching Introductory Statistics and Study Design to Residents in a Teaching Hospital

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## Abstract

The Research Design Center at the Tufts Clinical and Translational Science Institute (CTSI) has led more than 25 series of clinical research seminars across a variety of clinical departments. Each series consists of 5-7 non-credit seminars selected by the department and includes an introduction to research methods. Each seminar covers a specific study design or statistical topic and lasts an hour. The teaching objective is to provide clinician participants, primarily residents, with enough information about basic study design and statistics to increase their research comfort level. Engaging the full set of participants is difficult, as many residents are required to attend regardless of their interest in the content. We have found that using customized, example-based and highly participatory teaching methods helps to engage participants in the seminars. Evaluations are collected using 5-point Likert-scale questions (5=best). The mean responses for whether learning objectives were met, material was presented at an appropriate technical level, and overall satisfaction are 4.48, 4.38, and 4.43, respectively. Future directions for growth include advanced classes taught over several weeks, and increased tracking of the impact of the seminars.

**Key Words:** CTSA; biostatistics; epidemiology; teaching medical residents

## 1. Introduction

The Tufts CTSI was established in 2008 through a Clinical and Translational Science Award (CTSA) from the NIH (UL1 RR025752). One of the primary aims of the CTSI is to train investigators in research methods. To meet this aim, the CTSI provides both accredited degree programs offering doctoral and master's degrees, as well as a certificate program, in clinical and translational science. Non-accredited customized seminars covering more than 20 statistical and epidemiological topics are also offered through the CTSI and are the main focus of this paper.

The customized seminars were developed to provide basic information on key concepts to clinicians interested in research who do not have the time or funding to complete the formal, accredited programs offered by the Tufts CTSI. These seminars are not structured to teach researchers to design their own study or run statistical tests independently. Instead we try to give participants the tools they need to critically evaluate medical journal articles and to work with members of the CTSI Research Design Center (RDC) to design a research project, write protocols for smaller research projects and, ultimately, prepare a grant. We hope through these seminars to make the process of grant writing, from specific aims to study design to analytic plan, less intimidating.

Over the course of the past three years as we have designed and taught these seminars, we have tried many things to both engage residents and impart relevant information without overwhelming them. This paper will introduce our seminar program, discuss some of the challenges in teaching statistics and clinicians in a non-credit seminar series, and share what we have learned works best to engage residents in our seminars.

## 2. Overview of the Tufts CTSI Training Program

### 2.1 Basic Information

Hospital-based statisticians and epidemiologists at both the PhD and Master's level teach the seminars, which are designed to introduce key concepts, including advantages and disadvantages of various study designs as well as how to interpret the results of common statistical tests such as t-test, chi-square test, and regression models. The objectives generally are to provide participants with a greater understanding of the research process rather than specific technical skills. Because we focus on basic concepts and interpretation, our slide decks don't have any formulas and rarely discuss statistical assumptions other than to mention that they exist and should be checked by a statistician.

Due to scheduling difficulties in trying to find a single time that would work for multiple departments, most of our teaching is conducted at the departmental level during its regularly scheduled meetings, which usually gives us about 45 minutes per seminar. This allows most of the clinicians in the department to attend if they wish. Usually the residents and fellows are expected to attend. Other staff and faculty occasionally attend as well. Teaching at the departmental level allows us to customize the seminars using examples pulled from the literature read by members of that department. For example, if we are teaching to the Anaesthesiology department we will pull articles from the anaesthesiology journals. If a department is conducting research, we will use the data from their projects as examples if applicable and if they are willing to share for instructional purposes.

The department can choose just one or two seminars, or can choose to have a series of 5-7 seminars offered to the department over several weeks or several months. In a series we typically require at least one study design seminar before offering seminars on statistical topics. Within a series, a different instructor usually teaches each seminar.

Examples of our epidemiology seminars include "Why Studies Fail: Bias & Confounding," "Elements of a Protocol," and several different seminars on observational and experimental study designs. Popular statistics seminars include "Exploratory Data Analysis," "Which Statistical Test Should I Use?," "Pitfalls in Statistical Analyses," "Linear and Logistic Regression," and "Modeling Time-to-Event Outcomes." The full list of seminars with descriptions can be found at our website (<http://tuftsctsi.org/Services-and-Consultation/Education-in-Research-Methods/RDC-Educational-Seminars.aspx>).

Section 2.2 provides descriptions from our website for selected seminars.

### 2.2 Description of Selected Seminars

#### **Developing a Protocol (*pre-requisite: Designing Clinical Research*)**

This seminar presents key steps in developing study protocols. Basic understanding of different types of study design, as offered in our seminars, is expected. Required protocol elements, protocol implementation, ethical study design, and Institutional Review Board

issues will be addressed. Learning Objectives: By the end of this seminar, participants will be able to develop basic study protocols.

### **Exploratory Data Analyses**

A critical part of data analyses is a careful investigation of the collected sample data. Such explorations can help avoid later problems in the data analyses, assist with selecting the appropriate test statistic, and provide insights into the relationships between the study variables. This seminar presents approaches for exploring your data. Data from research studies are used to illustrate these approaches. Learning Objectives: Participants will understand the importance of preliminary data exploration and be able to discuss some data issues that these methods can help diagnose.

### **Linear and Logistic Regression**

This seminar introduces participants to linear and logistic regression, the most common types of regression. Discussion topics include how to choose when regression should be used, and how to decide which is most appropriate: linear or logistic regression. Topics covered include why regression is important, modeling strategies, and interpreting odds ratios and beta coefficients. Learning Objectives: By the end of this seminar, participants will be prepared to delineate the advantages of regression models, know whether to use linear or logistic regression, and be able to interpret the results.

## **2.3 Overall Goals**

We have three main goals for our training program. First, we introduce participants to core concepts in research methods. Second, we try to bring the participants into the Tufts CTSI research community and introduce them to our services, including help with study design, sample size calculations, and analytic plans for grants and protocols. Finally, we hope to increase participants' comfort level with research and analysis by introducing core concepts in an understandable and non-threatening way. We don't expect that at the end of the seminar, or even the end of the series, participants can write an analytic plan or come up with the best study design on their own. We do hope, however, that through becoming familiar with terms and concepts, they will have an idea of what we are talking about when they come to us for help.

## **2.4 Process**

The interested organizer, usually the department chair or education coordinator, contacts the CTSI. Although we have done some advertising for our training program, most of the organizers who contact us have heard about us through other departments who have taken our seminars or through another contact with the CTSI, who then informs them about the training program. The RDC Education Coordinator sets up a 30-45 minute meeting with the organizer to discuss his/her department's goals in setting up these seminars, and if needed, helps the organizer revise those goals to some that are more feasible, based on the limitations of our program. Once the goals have been solidified, we discuss which seminars will best meet those goals. Logistics such as the best time to meet, whether we will meet weekly or monthly, and whether the organizer would like reading or homework assignments as part of the series, are discussed. We also discuss whether research datasets from the department are available for use as examples during the series, and which journals department members most often read. The RDC Education Coordinator tries to get information from the organizer about who the expected audience is (residents/fellows vs. more experienced staff), the basic knowledge level of epidemiology and statistics of the participants, and whether they are required to do research projects.

Once the coordinator collects all the information, she emails the instructors with it, including dates and times for each seminar, and asks them to sign up to teach the seminars they are interested in. Finally, at the end of each seminar, an evaluation is collected.

## **2.5 Program Characteristics**

Since the program began in August 2008, almost 700 unique participants have come through our training program. Since many of them participated as part of a series, we have taught many of these participants multiple times. We have taught over 200 seminars to 35 groups, including 29 sets of series. We offer the seminars to all the affiliates of Tufts CTSI, including Tufts University, Tufts Medical Center and affiliated hospitals, and Tufts CTSI partners. At any given time, we have between 7 and 10 instructors available to teach the seminars. The program has flourished over the past 18 months, with up to 15 seminars per month in our busiest months.

**Table 1:** Program Characteristics from August 2008 through June 2011

Unique Participants Taught	681
Seminars Taught	218
Groups Taught	35
Series Taught	29
Number of Instructors	10

## **3. Teaching Approaches to Address Challenges in Teaching Residents**

There are many challenges in teaching epidemiology and statistics to residents and fellows, and these challenges are even more pronounced in a non-credit situation where attendance is either expected or mandatory. To address these challenges, we have significantly changed the way in which we teach the seminars over the past 12-18 months. Effective changes are described below.

### **3.1 Challenges in Teaching Residents and Fellows**

Many of the residents and fellows we teach are not interested in research, but are required to attend the seminars anyway as part of their regular education program. Even those who may be interested in research come with a wide variety in background knowledge and involvement in research. Although we usually provide a reading assignment in advance of the seminar, the participants may not read it, so we must assume that participants do not have any background knowledge of the seminar topic. Finally, we have a short exposure period compared to the traditional semester-long course. We typically schedule one hour per seminar, but due to late-arriving residents and fellows, we usually only have 45 minutes to teach. We also have only one seminar per topic, compared to several class sessions in a traditional course. Determining the correct amount of material that is feasible to teach well in such a short period is also difficult.

### **3.2 Teaching Approaches to Address the Challenges**

We have identified 4 key teaching approaches that help engage residents and lead to a more participation-based learning experience. In addition to these teaching approaches,

we have found that discussing the seminars and teaching in the RDC weekly meetings, as well as workshopping slide sets as a group, also help improve the seminars. Educating ourselves more about adult learning techniques and how clinicians learn, through consultations with Tufts Faculty Development and reading the adult learning literature, has helped us make needed changes. For the statistics seminars, one of the biggest changes we made was to move away from teaching statistics the way we learned them in our graduate studies. While teaching statistics the way we learned them may work in a traditional course for statistics majors, it certainly doesn't work for non-statisticians.

### *3.2.1 Customize seminars using articles or data from department's medical specialty*

Since we teach at the department level, we have the option of using examples from their own research data or from the journals that are specific to their medical specialty. Although customizing each slide deck each time we teach it to a different group in order to incorporate specific examples can be quite time-consuming, examples from within the specific medical specialty can help engage the participants throughout the seminar. One instructor teaching experimental study design to psychiatry residents found an article on a randomized trial comparing dolphin therapy to another water-based therapy(1). Because this was an unusual example, the participants were interested in knowing more about this study. The design and treatments allowed for an interesting discussion about potential bias and how to select an appropriate control intervention. If the department is involved in research and has datasets we can use, that also helps engage the residents. They are usually aware of the project, and may have been involved in helping collect the data.

### *3.2.2 Encourage high participation*

We try a variety of methods to encourage high participation and create an interactive seminar. We ask many questions and encourage the participants to share comments and ask questions throughout the seminar, rather than holding them until the end. We sometimes use clicker-response systems where a multiple-choice question is displayed and students use the i-clicker technology to anonymously choose the answer they think is best. A histogram of the responses is displayed and if there is wide variation in responses, it can lead to a rich discussion of why participants might have selected the answers they did and which is the correct response. Some of our seminars are predominantly discussion-based, with the instructor providing direction and an overview on the specific research approach.

### *3.2.3 Show how topics are useful to clinicians reading medical journal articles*

In an attempt to engage the residents who are not interested in research, we show how the seminar topics are relevant to evaluating and interpreting medical journal articles, which is applicable to all clinicians. Using examples from journal articles, and introducing key concepts and interpretation of key results rather than formulas and assumptions, help focus the seminars on knowledge items that are applicable to all clinicians. As the applicability is not necessarily obvious to the clinicians, it does help to point this out explicitly.


### *3.2.4 Use a specific medical example to introduce the problem and then move to the general approach*

Most of our seminars now use a medical example very early in the slide deck to motivate the problem and general approach to the problem, and plans are underway to convert all applicable seminars to this format. Figure 1 is pulled from the "Exploratory Data Analysis" slide deck and is the motivating example for the seminar. The instructor asks the participants if they think there is an association between smoking and lung function in

youth. As this is a published paper with a public-use dataset, this example leads into a discussion of appropriate study design and various graphical methods to visually examine the relationship between smoking and lung function in youth(2). Through the visual plots, the complete confounding between smoking status and age in young adults becomes apparent and is discussed. We have found this to be such a good example that we always use this example rather than customizing the example to the medical specialty of the group.

## Example: Lung Function and Smoking in Youth

- What is the association between smoking and lung function in youth?



[www.cigarettesflavours.com/category/youth-cigarettes-smoking](http://www.cigarettesflavours.com/category/youth-cigarettes-smoking)

EFFECTS OF CIGARETTE SMOKING ON LUNG FUNCTION IN ADOLESCENT BOYS AND GIRLS

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**EFFECTS OF CIGARETTE SMOKING ON LUNG FUNCTION IN ADOLESCENT BOYS AND GIRLS**

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**ABSTRACT**

**Background** Little is known about the sex-specific effects of cigarette smoking on the level and growth of lung function in adolescence, when 71 percent of people in the United States who smoke tried their first cigarette.

**Methods** We studied the effects of cigarette smoking on the level and rate of growth of pulmonary function in a cohort of 8168 boys and 4902 girls 10 to 18 years of age, examined annually between 1974 and 1989 in six cities in the United States.

**Results** We found a dose-response relation between smoking and lower levels of both the ratio of forced expiratory volume in one second to forced vital capacity (FEV<sub>1</sub>/FVC) and the forced expiratory

these sex differences may relate to the caliber of airways or to hormonal status at different stages of life. A higher prevalence of airway hyperresponsiveness in women who smoke than in men who smoke was partly explained by lower airway caliber in women, as measured by the absolute level of forced expiratory volume in one second (FEV<sub>1</sub>).<sup>4</sup> Exposure to cigarette smoke led to a greater increase in the number of mucus-producing tracheal goblet cells in female rats than in male rats; differences between the sexes were related to the estrous cycle.<sup>5,7</sup> We examined the sex-specific effects of smoking on the level and growth of lung function in children 10 to 18 years of age. We previously reported the associations between

**Figure 1: Motivating example slide from “Exploratory Data Analysis” seminar**

We also follow this approach of finding a very good example and then using that example for all our groups. One is for our “Steps of a Project” seminar where the supplementary information for the published article describes the thought processes and rationale of the authors along each step of the way, including study design, which treatment to use, and sample size calculations(3,4). Finally, we use an example for the “Linear and Logistic Regression” talk that motivates the importance of regression to understand associations when there is confounding.

For our other seminars, we still begin each seminar with a motivating example, but it is pulled from the medical specialty of the group we are teaching.

### *3.2.5 Personalize the lecture through humour and personal experiences*

We have the advantage of being a live presence in the room, which allows us to get to know the audience, assess their knowledge and background, and have personal communication with them. These interactions are very helpful in engaging participation of the residents. We also inject humour through cartoons or unusual examples, such as

the dolphin therapy example introduced previously, to lighten the mood. Sharing personal experiences related to the topic also helps spark the residents' interest in the topic.

Due to the wide variety of knowledge and interest in the topic within a given group, we need to be flexible and either cover less material for groups that have little knowledge, or be able to discuss more details and experiences for groups with a high level of knowledge. Although we try to assess the expected knowledge level when speaking with the organizer, he/she may either not know or not be correct. The ability to gauge participants' understanding, and then provide either less or more detail than listed on the slides on the fly, is critical to engaging residents in the seminar.

While all of the teaching approaches described in this section help engage residents, they do cut into our limited teaching time, which also limits the amount of material we can cover. We have discovered that this may be a good thing, though, as many of the initial slide decks for the various seminars tried to incorporate too much in a short time frame.

### *3.2.6 Active involvement of all instructors in improving seminars*

While not directly related to resident engagement during a seminar, active involvement of the instructors in our weekly meetings has also helped improve the seminars and series. As problems arise, we can address them as a group. We recently organized a series with a group at one of the affiliated hospitals. The organizer expected that 3<sup>rd</sup> and 4<sup>th</sup> year residents, who are required to complete a research project, as well as other staff involved in research, would attend. However, the audience ended up being mostly 1<sup>st</sup> year residents who would not be involved in research for several years. As a group we decided that some of the scheduled seminars, such as "Elements of a Protocol," were not appropriate or useful for this audience and ended up replacing that seminar with another and creating an extremely modified version of one of the other scheduled seminars in order to meet the interest and knowledge level of the audience. This modified version was so different that it is now listed as a separate seminar.

We share slide decks among all the instructors in an effort to keep the content similar for a given seminar, regardless of who teaches it. While the examples are still customized, the preparation time is less than it would be if each instructor created the slides from scratch. It also allows for constant improvement of the slide decks as each instructor makes some minor modifications to clarify a point. Occasionally we will spend time workshopping a specific slide set. Recent examples of workshopped slides include looking at the "Linear and Logistic Regression" and "Which Statistical Test Should I Use?" slide deck.

The regression slide deck had many formulas, including the logit, and showed details on assessing linearity. There were far too many slides for a 45-minute session and much of the information was not relevant to clinicians who would not be running their own logistic regression analyses. We decided that the most important thing we wanted our students to know was why regression is useful and how to interpret the main results from the models (odds ratios for logistic regression and beta coefficients for linear regression). A motivating example with clear confounders is used at the beginning of the lecture to lead into a discussion of confounding and multiple regression.

## 4. Evaluations

We collect evaluations at the end of each seminar. These evaluations ask both 5-point Likert-scale questions (5=Strongly Agree) and open-ended questions. Some of the Likert-scale questions used in our evaluations are shown below in Figure 2. The mean responses for whether learning objectives were met, whether material was presented at an appropriate technical level, and overall satisfaction are 4.48, 4.38 and 4.43, respectively. Open-ended questions ask about the most useful features of the seminar, how the seminar could be improved, and additional topics the participants would like to learn about.

The evaluations are shared immediately with the instructors so they can compare their assessment of how the seminar went with the experience of the participants. The open-ended questions generally provide more useful information than the Likert-scale questions.

	Strongly Disagree		Neutral		Strongly Agree
This program met its learning objectives:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The material was presented at an appropriate technical level:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Overall, I was satisfied with this program:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Figure 2:** Partial list of Likert-Scale questions asked on our evaluations given at the end of each seminar.

## 5. Future Directions

Future directions include adding more advanced seminars to meet the needs of participants who would like hands-on experience, improve evaluations to evaluate long-term impact of the series and whether our goals are being met, and continued opportunities for instructor development.

### 5.1 Intermediate course to residents interested in research

Some of the residents would like to learn how to run some basic analyses, but do not have the time or funding to take a semester-long biostatistics course. We plan to develop a 6-8 week seminar course to give participants hand-on experience in data analysis. This would be open to the entire CTSI community rather than a specific department. Attendance and completion of reading and homework assignments will be required and statistical software such as JMP or R Through Excel will be used. We may offer two courses: the first on analyzing proportions and categorical data and the second on analyzing means and continuous data. The focus of the first course will be on analysis of contingency tables, including the McNemar test, the Mantel-Haenszel test, the chi-square test, and the Fisher's Exact Test. The course will likely be taught in a computer lab and will be very interactive. The last 2 classes will introduce more advanced topics such as logistic regression, poisson regression, and generalized estimating equations, but will not teach the participants how to perform these models.



## 5.2 Improved Evaluations

Our current evaluations detail the participants' immediate responses to the seminar, but do not assess knowledge either short-term or long-term. Nor do they evaluate whether our goals are met, including whether participants are familiar with core research concepts, use other CTSI resources, or have an increased comfort level with research. We are working with the CTSI Evaluations Coordinator to develop an evaluation for the series as a whole, and follow-up evaluations 3-6 months after the series.

## 5.3 Instructor Development

We are constantly looking for opportunities for instructor development. We will continue to work with the director of the Tufts Faculty Development Office to improve our teaching. We also look for strengths within our own group for instructor development. One of our instructors has experience in case-based learning and will be present that technique to our instructors. The same instructor will also present tips and techniques to use in creating good PowerPoint slides.

## 6. Conclusion

Although difficult, it is possible to engage clinicians in a positive way in seminars introducing basic research methodology. Seminars using example-based, customized presentations that encourage high participation can succeed with these residents.

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