

Statistics in Biomedical Sciences

(3 credits)

Instructor: Yen-Hong Kuo, PhD.

Summary

- Existing statistics course: GSBS CTSC 5103S. GSNB 16:115:557 (index#: 22748) Wednesdays 4:30-7:30 PM in Fall 2016 semester.
- The course evaluation will be based on homework assignments (45%) and a final examination (55%).
- Syllabus suitable for PhD Students

Course Objectives

- Know the basic concepts of statistics
- Critically evaluate statistical methods used or described in news or research articles
- Appropriately apply basic statistical procedures using R
- Understand how to execute statistical tasks of a pre-clinical study and a clinical trial
- Understand how to implement rigor and transparency in NIH & AHRQ research grant applications
- Understand the transparent reporting to optimize the predictive value of preclinical research
- Learn the language of statistics.

Assignments for Evaluation:

- 1) **Homework Assignments (n=3) (45%)**
 - a. **Questions based on specific lecture topics**
 - i. **Use R to perform analysis**
 - ii. **Interpretation of results**
- 2) **Final Exam (55%)**
 - a. **In-class written exam**
- 3 **Grades: A, B, B+, C+, C, F**

Required Textbooks:

Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition (2013) by Wayne W. Daniel, Chad L. Cross

- ISBN-10: 1118302796, ISBN-13: 978-1118302798
- Available on Amazon at : http://www.amazon.com/Biostatistics-Foundation-Analysis-Probability-Statistics/dp/1118302796/ref=sr_1_1?ie=UTF8&qid=1378260999&sr=8-1&keywords=biostatistics%3A+a+foundation+for+analysis+in+the+health+sciences+10th+edition

Required Software:

R: A Language and Environment for Statistical Computing

- FREE
- Available from <http://www.r-project.org>

Required Readings (will keep updating)

Implementing Rigor and Transparency in NIH & AHRQ Research Grant Applications

- NIH Notice Number: NOT-OD-16-011
- <http://grants.nih.gov/grants/guide/notice-files/NOT-OD-16-011.html>

A call for transparent reporting to optimize the predictive value of preclinical research.

- Nature. 2012 Oct 11;490(7419):187-91. doi: 10.1038/nature11556.
- <http://www.ncbi.nlm.nih.gov/pubmed/23060188>

Rigor or mortis: best practices for preclinical research in neuroscience.

- Neuron. 2014 Nov 5;84(3):572-81 doi: 10.1016/j.neuron.2014.10.042.
- <http://www.ncbi.nlm.nih.gov/pubmed/25442936>

Statistical considerations for preclinical studies

- Exp Neurol. 2015 Aug;270:82-7. doi: 10.1016/j.expneurol.2015.02.024.
- <http://www.ncbi.nlm.nih.gov/pubmed/25725352>

References and Recommended Books

Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking

- Harvey Motulsky (1995, 1st Edition; 2010, 2nd Edition; 2013, 3rd Edition) Oxford University Press
- ISBN-13: 978-0195086072 (1995); 978-0199730063 (2010); 978-0199946648 (2013)

Principles of Biostatistics, 2nd Edition

- M. Pagano & K. Gauvreau (2000) Duxbury Press
- ISBN-10: 0534229026; ISBN-13: 978-0534229023

Fundamentals of Biostatistics

- Bernard Rosner (2005, 6th Edition; 2010, 7th Edition) Duxbury Press
- ISBN-13: 978-0534418205 (2005); 978-0538733496 (2010)

Recommended Course Schedule (the same as CTSC 5103S, other than the last one: "Final Examination" instead of "Project Presentation")

Date	Week	Topic	Readings
09/07/16	1	<p><u>Overview and Descriptive Statistics</u></p> <ul style="list-style-type: none"> a. Application of statistics in biomedical research b. Type of data c. Graphic representation of data d. Summary statistics: central tendency and dispersion e. Introduction to R 	Ch. 1, 2
09/14/16	2	<p><u>Probability and Probability Distributions</u></p> <ul style="list-style-type: none"> a. Probability b. Conditional probability c. Statistical methods in diagnostic medicine and screening test d. Binomial distribution e. Normal distribution 	Ch. 3, 4
09/21/16	3	<p><u>Estimation</u></p> <ul style="list-style-type: none"> a. Sampling distribution b. Confidence interval <ul style="list-style-type: none"> 1) Population means 2) Population proportions c. Sample size estimation based on accuracy of estimation <p><i>Homework Assignment Due: Summary Statistics</i></p>	Ch. 5, 6
09/28/16	4	<p><u>Hypothesis Testing</u></p> <ul style="list-style-type: none"> a. Type I error, Type II error b. Steps of performing hypothesis testing <ul style="list-style-type: none"> 1) Hypothesis testing on population means 2) Hypothesis testing on population proportions c. Power and sample size estimation 	Ch. 7
10/05/16	5	<p><u>Analysis of Variance</u></p> <ul style="list-style-type: none"> a. Comparisons between and among means b. Multiple comparisons <p><i>Homework Assignment Due: Confidence interval and hypothesis testing</i></p>	Ch. 8

Date	Week	Topic	Readings
10/12/16	6	<p><u>Analysis of Categorical Data</u></p> <ul style="list-style-type: none"> a. Chi-square test b. Relative risk and Odds ratio c. Sample size estimation based on proportions <p><i>Homework Assignment Due: Sample size estimation based on sample means</i></p>	<p>Ch. 12</p> <p>Ch. 15</p>
10/19/16	7	<p><u>Statistical Analysis Plan in Clinical and Pre-Clinical Trials</u></p> <ul style="list-style-type: none"> a. Study design in drug development b. Statistical considerations <ul style="list-style-type: none"> 1) Sample size determination 2) Endpoint definitions 3) Analyses (safety, efficacy) 4) Interim analyses c. Best practice for preclinical research (blinding, random assignment, biological variable consideration, inclusion and exclusion criteria, replicates and pseudo-replicates, validation of reagents and assays) d. Implement rigor and transparency in NIH & AHRQ research grant applications 	Handouts
10/26/16	8	<p><u>Correlation and Regression</u></p> <ul style="list-style-type: none"> a. Correlation b. Simple linear regression <p><i>(CTSC 5103S) Project Part I Due: Statistical Analysis Plan</i></p>	Ch. 9
11/02/16	9	<p><u>Multiple Linear Regression and Logistic Regression</u></p> <ul style="list-style-type: none"> a. Multiple linear regression b. Model building and diagnosis c. Logistic regression 	Ch. 10, 11
11/09/16	10	<p><u>Nonparametric Statistics</u></p> <ul style="list-style-type: none"> a. Sign test b. Wilcoxon sign rank test c. Wilcoxon rank sum test d. Kruskal Wallis test 	Ch. 13
11/16/16	11	<p><u>Survival Analysis</u></p> <ul style="list-style-type: none"> a. Kaplan-Meier procedure b. Log-rank test c. Cox proportional hazard model <p><i>Homework Assignment Due: Regression Analysis and Nonparametric Analysis</i></p>	Ch. 14

Date	Week	Topic	Readings
11/23/16	12	<p><u>Biostatistics in the Genomic Age</u></p> <p>a. Microarray data analysis</p> <p><i>Review Assigned Readings</i></p>	Handouts
11/30/16	13	<p><u>Pharmacoepidemiology and Meta-Analysis</u></p> <p>a. Drug utilization b. Drug safety c. Drug effectiveness</p> <p><u>Biostatistics in the Genomic Age</u></p> <p>a. Microarray data analysis</p> <p><i>(CTSC 5103S) Project Part II Due: Statistical Analysis Report</i></p>	Handouts
12/07/16	14	<p><u>Reading the Medical Literature</u></p> <p>a. Use of statistical analysis in medical literature b. Misuse of statistical analysis in medical literature c. The transparent reporting to optimize the predictive value of preclinical research</p>	Handouts
12/14/16	15	<p><u>Final Examination</u></p> <p>a. In-class written examination</p> <p><u>Project Presentation (CTSC 5103S)</u></p> <p>a. <i>Power Point presentation of Projects</i></p>	

Proposed Covered Topics in Details

Chapter and Title	Section and Topics
1. Introduction To Biostatistics.	1.2 Some Basic Concepts.
1. Introduction To Biostatistics.	1.3 Measurement and Measurement Scales.
1. Introduction To Biostatistics.	1.4 Sampling and Statistical Inference.
1. Introduction To Biostatistics.	1.5 The Scientific Method and the Design of Experiments.
1. Introduction To Biostatistics.	1.6 Computers and Biostatistical Analysis.
2. Descriptive Statistics.	2.2 The Ordered Array.
2. Descriptive Statistics.	2.4 Descriptive Statistics: Measures of Central Tendency.
2. Descriptive Statistics.	2.5 Descriptive Statistics: Measures of Dispersion.
3. Some Basic Probability Concepts.	3.2 Two Views of Probability: Objective and Subjective.
3. Some Basic Probability Concepts.	3.3 Elementary Properties of Probability.
3. Some Basic Probability Concepts.	3.4 Calculating the Probability of an Event.
3. Some Basic Probability Concepts.	3.5 Bayes' Theorem, Screening Tests, Sensitivity, Specificity, and Predictive Value Positive and Negative.
4. Probability Distributions.	4.2 Probability Distributions of Discrete Variables.
4. Probability Distributions.	4.3 The Binomial Distribution.
4. Probability Distributions.	4.4 The Poisson Distribution.
4. Probability Distributions.	4.5 Continuous Probability Distributions.
4. Probability Distributions.	4.6 The Normal Distribution.
4. Probability Distributions.	4.7 Normal Distribution Applications.
5. Some Important Sampling Distributions.	5.2 Sampling Distributions.
5. Some Important Sampling Distributions.	5.3 Distribution of the Sample Mean.
5. Some Important Sampling Distributions.	5.4 Distribution of the Difference Between Two Sample Means.
5. Some Important Sampling Distributions.	5.5 Distribution of the Sample Proportion.
5. Some Important Sampling Distributions.	5.6 Distribution of the Difference Between Two Sample Proportions.
6. Estimation.	6.2 Confidence Interval for a Population Mean.
6. Estimation.	6.3 The t Distribution.
6. Estimation.	6.4 Confidence Interval for the Difference Between Two Population Means.
6. Estimation.	6.5 Confidence Interval for a Population Proportion.
6. Estimation.	6.6 Confidence Interval for the Difference Between Two Population Proportions.
6. Estimation.	6.7 Determination of Sample Size for Estimating Means.
6. Estimation.	6.8 Determination of Sample Size for Estimating Proportions.
7. Hypothesis Testing.	7.2 Hypothesis Testing: A Single Population Mean.
7. Hypothesis Testing.	7.3 Hypothesis Testing: The Difference Between Two Population Means.
7. Hypothesis Testing.	7.4 Paired Comparisons.
7. Hypothesis Testing.	7.5 Hypothesis Testing: A Single Population Proportion.
7. Hypothesis Testing.	7.6 Hypothesis Testing: The Difference Between Two Population Proportions.
7. Hypothesis Testing.	7.9 The Type II Error and the Power of a Test.
7. Hypothesis Testing.	7.10 Determining Sample Size to Control Type II Errors.
8. Analysis Of Variance.	8.2 The Completely Randomized Design.
9. Simple Linear Regression And Correlation.	9.2 The Regression Model.
9. Simple Linear Regression And Correlation.	9.3 The Sample Regression Equation.
9. Simple Linear Regression And Correlation.	9.4 Evaluating the Regression Equation.
9. Simple Linear Regression And Correlation.	9.5 Using the Regression Equation.

9. Simple Linear Regression And Correlation.	9.6 The Correlation Model.
9. Simple Linear Regression And Correlation.	9.7 The Correlation Coefficient.
9. Simple Linear Regression And Correlation.	9.8 Some Precautions.
10. Multiple Regression And Correlation.	10.2 The Multiple Linear Regression Model.
10. Multiple Regression And Correlation.	10.3 Obtaining the Multiple Regression Equation.
10. Multiple Regression And Correlation.	10.4 Evaluating the Multiple Regression Equation.
10. Multiple Regression And Correlation.	10.5 Using the Multiple Regression Equation.
11. Regression Analysis: Some Additional Techniques.	11.2 Qualitative Independent Variables.
11. Regression Analysis: Some Additional Techniques.	11.3 Variable Selection Procedures.
11. Regression Analysis: Some Additional Techniques.	11.4 Logistic Regression.
12. The Chi-Square Distribution And The Analysis Of Frequencies.	12.2 The Mathematical Properties of the Chi-Square Distribution.
12. The Chi-Square Distribution And The Analysis Of Frequencies.	12.4 Tests of Independence.
12. The Chi-Square Distribution And The Analysis Of Frequencies.	12.5 Tests of Homogeneity.
12. The Chi-Square Distribution And The Analysis Of Frequencies.	12.6 The Fisher Exact Test.
12. The Chi-Square Distribution And The Analysis Of Frequencies.	12.7 Relative Risk, Odds Ratio, and the Mantel–Haenszel Statistic.
13. Nonparametric And Distribution-Free Statistics.	13.2 Measurement Scales.
13. Nonparametric And Distribution-Free Statistics.	13.3 The Sign Test.
13. Nonparametric And Distribution-Free Statistics.	13.4 The Wilcoxon Signed-Rank Test for Location.
13. Nonparametric And Distribution-Free Statistics.	13.6 The Mann–Whitney Test.
13. Nonparametric And Distribution-Free Statistics.	13.8 The Kruskal–Wallis One-Way Analysis of Variance by Ranks.
13. Nonparametric And Distribution-Free Statistics.	13.10 The Spearman Rank Correlation Coefficient
14. Survival Analysis.	14.2 Time-to-Event Data and Censoring
14. Survival Analysis.	14.3 Kaplan-Meier Procedure
14. Survival Analysis.	14.4 Comparing Survival Curves
14. Survival Analysis.	14.5 Cox Regression: The Proportional Hazards Model
15. Vital Statistics.	15.2 Death Rates and Ratios.
15. Vital Statistics.	15.3 Measures of Fertility.
15. Vital Statistics.	15.4 Measures of Morbidity.
Extra	McNemar's Test
Extra	Determine sample size based on means and standard deviations from two samples
Extra	Determine sample size based on proportions from two samples
Extra	Statistical Analysis Plan
Extra	Reading the medical literature
Extra	Implement rigor and transparency in NIH & AHRQ research grant applications
Extra	The transparent reporting to optimize the predictive value of preclinical research
Extra	Best practices for Preclinical research (including: blinding, random assignment, biological variable consideration, inclusion and exclusion criteria, replicates and pseudo-replicates, validation of reagents and assays)