Statistics and Experimental Design for the Biomedical Sciences

MCP8050C
Spring Semester 2021
Syllabus & Schedule

Statistics and Experimental Design for the Biomedical Sciences is a practical course designed to provide students with a solid foundation and intuitive understanding of statistics for the biomedical sciences. The course covers key concepts and methods. The course deals with best practice in experimental design and statistical analysis, ensuring scientific rigor and reproducibility. The course emphasizes parametric and nonparametric statistics used in making between-group inferences, linear and nonlinear regression used in modeling physiological phenomena, effective data presentation, transparency, and graphic integrity. This 3-credit-hour course comprises both lectures and workshops.

Learning Outcomes
1. Calculate the probability of random events
2. By using probability distributions, judge whether an observation is unlikely to have arisen randomly and whether we can safely declare an effect real
3. Design powerful experiments in the biomedical sciences, incorporating appropriate controls and accounting for confounding variables
4. Estimate sample size required for sufficient power and calculate post hoc the power of a statistical test
5. Identify the factors and levels in a multifactorial experimental design, and define the family of comparisons of interest in any experiment
6. Collect, organize, summarize, analyze, and communicate data honestly and effectively
7. Make inferences (reach conclusions) about the population(s) when only sample data are known
8. Select and execute the most appropriate statistical test to make inferences from available data, frame the null hypothesis, and declare the significance of the effect if one exists
9. Fit observed data by an appropriate linear or nonlinear function in order to describe physiological phenomena

Instructors
Course Director: Bryan Mackenzie, PhD  ●  Email: bryan.mackenzie@uc.edu
Tel: 513-558-3627  ●  Office: MSB 4257A  ●  Office hours: By appointment

Lecturer: John N Lorenz, PhD  ●  Email: john.lorenz@uc.edu
Tel: 513-558-3097  ●  Office: MSB 4259  ●  Office hours: By appointment

Graduate Teaching Assistants: To Be Named

Undergraduate SI Leader: To Be Named
Supplemental Instruction (SI) is offered for this course by UC's Learning Assistance Center. Students of all academic levels are invited to participate in SI sessions. SI sessions are group-study opportunities scheduled once per week, independently of the workshops. They are facilitated by your SI leader, who is attending class and preparing SI sessions based on the class content. SI sessions utilize a collaborative learning model to aid in comprehension and synthesis of course material and development of effective study techniques. On average, students who regularly participate in SI sessions earn a higher final course grade, as well as higher exam grades, than do students who choose not to participate in SI. Attendance is voluntary and is not a substitute for class attendance.
### Registration

<table>
<thead>
<tr>
<th>Course #</th>
<th>Section</th>
<th>Credits</th>
<th>Class Schedule</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP8050C</td>
<td>002</td>
<td>3 G</td>
<td>Tuesdays 2:00 – 3:20 pm</td>
<td>MSB 7051 Uptown Campus–East</td>
</tr>
<tr>
<td>GNTD8050C GRADUATE</td>
<td></td>
<td></td>
<td>Tuesdays 2:00 – 3:50 pm</td>
<td>MSB E255 Uptown Campus–East</td>
</tr>
<tr>
<td></td>
<td>004</td>
<td>3 G</td>
<td>Tuesdays 2:00 – 3:20 pm</td>
<td>MSB 7051 Uptown Campus–East</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thursdays 2:00 – 3:50 pm</td>
<td>MSB E255 Uptown Campus–East</td>
</tr>
<tr>
<td></td>
<td>006</td>
<td>3 G</td>
<td>Tuesdays 2:00 – 3:20 pm</td>
<td>MSB 7051 Uptown Campus–East</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fridays 10:30 am – 12:20 pm</td>
<td>MSB E255 Uptown Campus–East</td>
</tr>
</tbody>
</table>

### Assessment

Assessment in this course comprises both formative and summative assessment, intended to provide a holistic view of how well the student is assimilating and synthesizing information, developing both a theoretical and practical understanding of experimental design, statistical analysis and interpretation, and developing critical skills. Formative assessment offers the student continuous feedback and guidance. Summative assessment provides the course director with a means of evaluating knowledge gained and proficiency achieved by the student.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Details</th>
<th>Assessment type</th>
<th>Graded/Contribution to overall course grade*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Discussion</td>
<td>Class participation¹</td>
<td>Formative</td>
<td>Required, nongraded</td>
</tr>
<tr>
<td>Workshops</td>
<td>Class participation¹</td>
<td>Formative</td>
<td>Required, nongraded</td>
</tr>
<tr>
<td>Office Hours/SI Review Sessions</td>
<td>See Blackboard</td>
<td>Formative</td>
<td>Not required, nongraded</td>
</tr>
<tr>
<td>Assignments²</td>
<td>See Blackboard</td>
<td>Formative</td>
<td></td>
</tr>
<tr>
<td>Pop Quizzes</td>
<td>During lecture</td>
<td>Formative</td>
<td>[Graded (10%)]</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>Multiple-choice test</td>
<td>Summative³</td>
<td>Graded (25%)</td>
</tr>
<tr>
<td>Final Exam Part I</td>
<td>Multiple-choice test</td>
<td>Summative³</td>
<td>Graded (30%)</td>
</tr>
<tr>
<td>Final Exam Part II</td>
<td>Practical exam</td>
<td>Summative³</td>
<td>Graded (35%)</td>
</tr>
</tbody>
</table>

¹Required participation includes (1) participating in class discussions on lecture days and (2) presenting solutions to problems given in the weekly workshops. For Workshop 12, students will work within small groups to present a critique of the experimental design, statistical methods and reporting in a published paper, and then submit individually a written critique.

²Assignments will be administered via Blackboard. Late assignments will not be awarded credit.

³Summative assessments will not be made available to the student for review after the exam.

### Grading

Grades will be assigned as follows, with no adjustment for the distribution of scores.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>90.0%–100%</td>
</tr>
<tr>
<td>A−</td>
<td>85.0%–89.9%</td>
</tr>
<tr>
<td>B</td>
<td>82.0%–84.9%</td>
</tr>
<tr>
<td>B−</td>
<td>74.0%–76.9%</td>
</tr>
<tr>
<td>B+</td>
<td>77.0%–81.9%</td>
</tr>
<tr>
<td>C</td>
<td>70.0%–73.9%</td>
</tr>
<tr>
<td>C*</td>
<td>67.0%–69.9%</td>
</tr>
</tbody>
</table>

**NB:** To obtain a passing grade of C or better, you must earn from the three formal examinations (midterm, final part I, final part II) an aggregate score that is equivalent to a satisfactory grade, i.e. 67%. Even if your total score for the course (including regular assignments and any make-up assignments) is ≥ 67%, if your aggregate score for the formal examinations is < 67%, you will receive an F grade.

### Attendance

Attendance is required

### Prerequisites

None

### Auditing

Auditing requires advance permission of the Course Director

### Web Page

http://med.uc.edu/systemsbiology/studycourse/statistics or http://med.uc.edu/msinphysiology/curriculum/statistics-and-experimental-design
Canvas & Email Policy
Announcements and messages sent via Canvas or via UC email will be considered sufficient notice. You should not communicate with instructors from a non-UC email account.

Workshop, Practical Exam, and Required Software
You must have a professional laptop computer on which you have installed SigmaPlot (v14 preferred). You can purchase a site-licensed copy of SigmaPlot for $74 ($42 after February 1, 2020). The license expires July 31, 2020. SigmaPlot requires the Windows OS. To run SigmaPlot on your mac you will have to either (1) use a Windows compatibility layer (eg CrossOver Mac) in which you run SigmaPlot, or (2) partition your disk (using Bootcamp) and install Windows on that partition. If you have an earlier version of SigmaPlot, you may find it difficult to follow along in workshops.

Purchase UC site-licensed software online:
https://www.uc.edu/about/ucit/services/hardware-software-students/software-students.html

*Note that Minitab, SAS, SPSS, and SYSTAT input data formats are supported in SigmaPlot. You may elect to use an alternative statistics software package (e.g. Minitab, Prism, SAS, SPSS, SYSTAT) instead of SigmaPlot. Should you choose to do so you acknowledge the following: (1) no provision will be made to ensure that data files are compatible, (2) you are responsible for any reformatting or reorganization of data that may be required, (3) following along at the workshop may be difficult; and (4) no troubleshooting or instruction will be provided for alternative software.

Textbooks
Reference to textbooks and online eTexts is strongly recommended as you study for this course. Each module lists/links additional reading material. Some recommended eTexts are linked from the Blackboard class under Web Resources → eTexts and Applets. Recommended textbooks include:

Philip Rowe (2016) Essential Statistics for the Pharmaceutical Sciences, 2e, Wiley, Chichester
ISBN: 9781118913383 (cloth)
ISBN: 9781118913390 (paperback)
Free online access (on-campus or connected to UC via VPN):

A very accessible, easy-to-read textbook Essential Statistics will help you gain a solid understanding of statistics and good practice. Rowe walks the reader through the most common statistical tests and is careful to point out the many pitfalls that researchers can encounter.

ISBN: 9780123848642 (hardback)
Free online access (on-campus or connected to UC via VPN):

A thorough and comprehensive statistics manual for biomedical and clinical research, Statistics in Medicine will also serve as an excellent reference for many of the tests that are beyond the scope of this course.

Special Needs Policy
If you have any special needs related to your participation in this course, including identified visual impairment, hearing impairment, physical impairment, communication disorder, and/or specific learning disability that may influence your performance in this course, you should meet with the instructor to arrange for reasonable provisions to ensure an equitable opportunity to meet all the requirements of this course. At the discretion of the instructor, some accommodations may require prior approval by Disability Services.
Academic Integrity Policy

The University Rules, including the Student Code of Conduct, and other documented policies of the department, college, and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism or cheating, will be dealt with on an individual basis according to the severity of the misconduct.

Counseling Services

Students have access to counseling and mental health care through the University Health Services (UHS), which can provide both psychotherapy and psychiatric services. In addition, Counseling and Psychological Services (CAPS) can provide professional counseling upon request; students may receive five free counseling sessions through CAPS without insurance. Students are encouraged to seek assistance for anxiety, depression, trauma/assault, adjustment to college life, interpersonal/relational difficulty, sexuality, family conflict, grief and loss, disordered eating and body image, alcohol and substance abuse, anger management, identity development and issues related to diversity, concerns associated with sexual orientation and spirituality concerns, as well as any other issue of concerns. After hours, students may call UHS at 513-556-2564 or CAPS Cares at 513-556-0648. For urgent physician consultation after hours, students may call 513-584-7777.

Title IX

Title IX is a federal civil rights law that prohibits discrimination on the basis of your actual or perceived sex, gender, gender identity, gender expression, or sexual orientation. Title IX also covers sexual violence, dating or domestic violence, and stalking. If you disclose a Title IX issue to me, the course director, I am required to forward that information to the Title IX Office. They will follow up with you about how the University can take steps to address the impact on you and the community and make you aware of your rights and resources. Their priority is to make sure you are safe and successful here. You are not required to talk with the Title IX Office. If you would like to make a report of sex or gender-based discrimination, harassment or violence, or if you would like to know more about your rights and resources on campus, you can consult the website www.uc.edu/titleix or contact the office at 513-556-3349.

Course Format

The course comprises a weekly lecture (Tuesdays 2:00 – 3:20 pm) followed by a weekly workshop (you will attend either Wednesdays 2:00 – 3:50 pm or Thursdays 2:00 – 3:50 pm).

Module 1 Introduction to Statistics I: Basic Concepts; Probability and Distributions

Module 2 Introduction to Statistics II: Descriptive Statistics; Hypothesis Testing

Module 3 Between-Group Inferences I: Student’s t Tests (One-Sample, Two-Sample, Paired)

Module 4 Between-Group Inferences II: Nonparametric Testing (Rank-Sum Test, Signed-Rank Test, and Sign Test)

Module 5 Between-Group Inferences III: Chi-Square Test, Fisher’s Exact Test, and Analysis of Frequencies; Odds Ratios and Relative Risk; ROC Analysis

Module 6 Between-Group Inferences IV: Analysis of Variance and Multiple Comparisons

Module 7 Experimental Design; Multifactorial Analysis

Module 8 Survival Analysis; False-Discovery Rate Procedure; Permutation Methods; Normalization; Analysis of qPCR Data

Module 9 Power Analysis; Sample-Size Estimation; Transparency, Rigor and Reproducibility

Module 10 Multiple Linear Regression; Model Improvements

Module 11 Statistical Reporting, Data Presentation, and Graphic Integrity

Module 12 Critiquing Experimental Design and Statistical Analyses of Published Articles

Module 13 Review