Statistics and Experimental Design for the Biomedical Sciences

MEDS3023C
Summer 2023
Second Half Term | Session E
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 covers 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.

Summer 2023, the course is taught online, combining recorded lectures and active-learning approaches. Your attendance is required at Recitations and Workshops. The Graduate Teaching Assistant also offer office hours and review sessions ad hoc. These sessions may be offered in-person or online; they are optional but strongly recommended to help you stay on track to attain your goals in this course.

Instructors

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

Graduate Teaching Assistant: Corbin R Azucenas, BS | Email: azucencr@mail.uc.edu
Office Hours: TBA | Location: TBA

Lecturer (Lecture 7): John N Lorenz, PhD | Email: john.lorenz@uc.edu
Tel: 513-558-3097 | Office: MSB 4259 | Office hours: By appointment

Registration

Course #	Section	Credit Hours	Class #	Class Schedule	Location
MEDS3023C UNDERGRADUATE	**001**	3 U	73679	Tue 2:00 – 3:20 pm Wed 4:00 – 5:50 pm Fri 2:00 – 3:50 pm	Canvas Canvas Canvas

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 appropriate linear or nonlinear functions to describe physiological phenomena

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.

Assessment	Details	Assessment type	Graded/Contribution to overall course grade*
Class Discussions	Class participation[1]	Formative	Required, nongraded
Workshops	Class participation[1]	Formative	Graded (30%)
Office Hours	See Canvas	Formative	Not required, nongraded
Assignments[2]	See Canvas	Formative	Graded (12%)
Pop Quizzes	During recitation	Formative	Graded (3%)
Midterm Exam	Multiple-choice test	Summative[3]	Graded (25%)
Final Exam	Multiple-choice test	Summative[3]	Graded (30%)

[1]Required participation includes (1) participating in class discussions at recitations and workshops, and (2) presenting solutions to problems given in the workshops.

[2]Assignments will be administered via Canvas. Your assignment must be submitted in Canvas. Late submissions will not be awarded credit.

[3]Summative 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.

A	90.0%–100%	**B**	77.0%–81.9%	**C***	67.0%–69.9%	**D**	55.0%–58.9%
A–	85.0%–89.9%	**B–**	74.0%–76.9%	**C–**	63.0%–66.9%	**D–**	50.0%–54.9%
B+	82.0%–84.9%	**C+**	70.0%–73.9%	**D+**	59.0%–62.9%	**Fail**	Below 50.0%

***NB:** To earn a satisfactory grade of C or better, you must earn from the three formal examinations (midterm exam, final exam part 1, final exam part 2) an aggregate score that is equivalent to a satisfactory grade, i.e. 67%. If your total score for the course (including regular assignments and any make-up assignments) is ≥ 67% but your aggregate score for the formal examinations is < 67%, you will receive at most a C– grade.

Attendance Attendance is required at all online Recitation and Workshop class meetings

Auditing Auditing requires advance permission of the Course Director

Web Page https://med.uc.edu/education/undergraduate-education/undergraduate-program-in-medical-sciences/undergraduate-courses/3023c-statistics-and-experimental-design-for-the-biomedical-sciences

Canvas & Email Policy Announcements and messages sent via Canvas or via UC email will be considered sufficient notice. It is your responsibility to check notification settings in your Canvas account to ensure that you receive announcements. You should not communicate with instructors from a non-UC email account—any such communication will be ignored.

Technology/ Hardware Requirements

You must have a professional laptop computer. You will also need to obtain statistical software or be able to access it remotely as described below. If any of these requirements create a challenge for you, please contact your program director as soon as possible.

Required Statistical Software

You must obtain an appropriate statistical software or be able to access it remotely. SigmaPlot v15 is the recommended software package for use in this course. (Under exceptional circumstances, you may use an alternative software package, see below*.)

Your options for purchasing or remotely accessing SigmaPlot:

1. Purchase a UC site-licensed copy of SigmaPlot v15 for $38. The license expires July 31, 2023. Visit IT@UC ResNet Software Store at https://secure.touchnet.net/C21575_ustores/web/product_detail.jsp?PRODUCTID=757&SINGLESTORE=true
2. Purchase your own personal copy of SigmaPlot v15 from Systat software at https://systatsoftware.com/sigmaplot/
3. Access SigmaPlot v15 remotely at UC's VirtualLab: You can connect to UC's VirtualLab and remotely use SigmaPlot on a UC computer. Be advised that VirtualLab is subject to concurrent-user capacity limits. (i) Save the SigmaPlot data files that you will need on your UC OneDrive; (ii) Go to https://mydesk.uc.edu and log in (you do not need to install the client); (iii) Click on the "Student Desktops" icon; (iv) Log in to OneDrive; (v) You will find the SigmaPlot icon on the desktop (after logging in, wait a few seconds before launching SigmaPlot); (vi) Be sure to save your analyses, and export reports or figures (e.g. as jpeg), to your OneDrive.
4. Using a mac: SigmaPlot runs on the Windows OS. To run SigmaPlot on your mac you will have to either (i) use a Windows compatibility layer (e.g. CrossOver Mac) in which you run SigmaPlot, or (ii) partition your disk (using Bootcamp) and install Windows on that partition. More information: https://systatsoftware.com/products/sigmaplot/run-sp-on-a-mac/

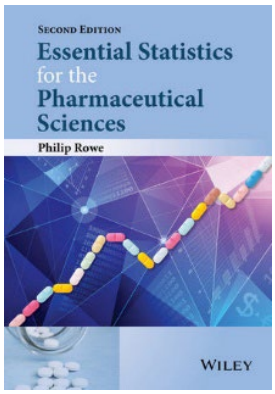
***Using an alternative statistical software package:**

Minitab, SAS, SPSS, and SYSTAT input data formats are supported in SigmaPlot. You may elect to use an alternative statistical software package (e.g. Minitab, Prism, R environment, 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. Can you guess, I do not recommend this option? But it's a free world.

Technical/IT Support | ResNet

For all technical or IT support including but not limited to (1) installing your UC site-licensed copy of SigmaPlot, (2) help or advice in partitioning your mac to install Windows, and (3) all other hardware or software support, please contact ResNet, UCit's walk-in and remote help service, see https://www.uc.edu/about/ucit/help/resnet.html. Please do not contact any of the course instructors for technical support.

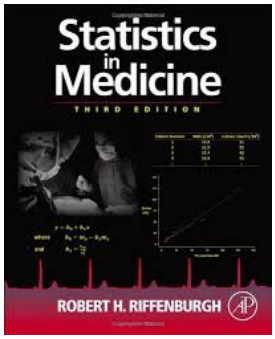
Textbooks Reference to textbooks and online eTexts is strongly recommended as you study for this course. Each module lists/links additional reading material. Some recommended eTexts are linked from the Canvas class under the Resources tab. Recommended textbooks include:



Philip Rowe (2016) *Essential Statistics for the Pharmaceutical Sciences*, 2e,
Wiley, Chichester
ISBN: 9781118913383 (cloth)
ISBN: 9781118913390 (paperback)
ISBN: 9781119109075 (e-book)

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.

Free Online Access—On Campus
http://onlinelibrary.wiley.com/book/10.1002/9781119109075
Free Online Access—Off Campus
http://uc.idm.oclc.org/login?url=http://onlinelibrary.wiley.com/book/10.1002/9781119109075



Robert Riffenburgh (2013) *Statistics in Medicine*, 3e,
Academic Press/Elsevier, San Diego
ISBN: 9780123848642 (hardback)
ISBN: 9780123848659 (e-book)

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.

Free Online Access—On Campus
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http://uc.idm.oclc.org/login?url=http://www.sciencedirect.com/science/book/9780123848642

Pre- & Co-requisites, Breadth of Knowledge (BoK) areas, Baccalaureate Competencies

There are no pre- or co-requisites for this course. MEDS3023C Statistics & Experimental Design for the Biomedical Sciences forms part of the UC General Education Program designated by the designated Breadth of Knowledge (BoK) area Quantitative Reasoning (QR).

Quantitative reasoning skills are a significant element of the course. The course meets the QR designation because it contains discussion, instruction, use (on the part of the student), and assessment of:

- Creation and interpretation of mathematical models (such as formulas, graphs, tables, and schematics) and inferences from such models
- Representation of mathematical (quantitative) information symbolically, visually, numerically, and verbally
- Problem solving using logical and statistical methods
- Evaluation of solutions to mathematical problems (estimate, check answers, identify alternative, select optimal results, and recognize limits of the methods)

You can find more information about Breath of Knowledge and Baccalaureate Competencies by visiting the Gen Ed website at https://www.uc.edu/about/provost/colleges-and-offices/offices/undergraduate-affairs/gen-ed-core-rd/definitions.html.

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.

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.

Student Religious Accommo-dation Ohio law and the university's Student Religious Accommodations for Courses Policy 1.3.7 permits a student, upon request, to be absent for reasons of faith or religious or spiritual belief system or to participate in organized activities conducted under the auspices of a religious denomination, church, or other religious or spiritual organization and/or to receive alternative accommodations with regard to examinations and other course requirements due to an absence permitted for the reasons described above. Not later than fourteen days after the first day of instruction in the course, the student should provide the course director with written or email notice of the specific dates for which the student requests alternative accommodations. For additional information about this policy, please contact the Executive Director of the Office of Equal Opportunity and Access at (513) 556-5503 or oeohelp@ucmail.uc.edu.

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 based on 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.

Statistics and Experimental Design for the Biomedical Sciences — MEDS3023C–001
Summer 2023
Second Half Term | Session E

Date	Format	Topic	Instructor
Learning Module 1	**Introduction to Statistics: Basic Concepts; Probability and Distributions; Descriptive Statistics; Hypothesis Testing**		
Fri 23 Jun	Lecture 1	Introduction to Statistics 1: Basic Concepts; Probability and Distributions	Mackenzie
Asynchronous	Lecture 2	Introduction to Statistics 2: Descriptive Statistics; Hypothesis Testing	Mackenzie
Tue 27 Jun	Recitation for Lectures 1/2	Introduction to Statistics: Basic Concepts; Probability and Distributions; Descriptive Statistics; Hypothesis Testing	Mackenzie
Wed 28 Jun	Workshop 1	Probability and Probability Distributions; Introduction to SigmaPlot v15	Mackenzie
Fri 30 Jun	Workshop 2	Descriptive Statistics; Hypothesis Testing	Mackenzie
Fri 30 Jun	**Assignment 1** | What do you hope to achieve or learn? | Due 6:00 pm		
Learning Module 2	**Between-Group Inferences (A): *t* Tests and Nonparametric Analogs (Rank-Sum Test, Signed-Rank Test, and Sign Test)**		
Asynchronous	Lecture 3	Between-Group Inferences 1: *t* Tests	Mackenzie
Asynchronous	Lecture 4	Between-Group Inferences 2: Nonparametric Testing (Rank-Sum Test, Signed-Rank Test, and Sign Test)	Mackenzie
Wed 5 Jul, 11:00 am – 12:20 pm	Recitation for Lectures 3/4	Between-Group Inferences (A): t Tests and Nonparametric Analogs (Rank-Sum Test, Signed-Rank Test, and Sign Test)	Mackenzie
Wed 5 Jul	Workshop 3	Between-Group Inferences 1: *t* Tests	Azucenas
Fri 7 Jul	Workshop 4	Between-Group Inferences 2: Nonparametric Testing (Rank-Sum Test, Signed-Rank Test, and Sign Test)	Mackenzie
Learning Module 3	**Between-Group Inferences (B): Analysis of Frequencies; ROC Analysis; Analysis of Variance and Multiple Comparisons**		
Asynchronous	Lecture 5	Between-Group Inferences 3: Chi-Square Test, Fisher's Exact Test, and Analysis of Frequencies; Odds Ratios and Relative Risk; ROC Analysis	Mackenzie
Asynchronous	Lecture 6	Between-Group Inferences 4: Analysis of Variance and Multiple Comparisons	Mackenzie
Tue 11 Jul	Recitation for Lectures 5/6	Between-Group Inferences (B): Analysis of Frequencies; ROC Analysis; Analysis of Variance and Multiple Comparisons	Mackenzie
Wed 12 Jul	Workshop 5	Between-Group Inferences 3: Chi-Square Test, Fisher's Exact Test, and Analysis of Frequencies; Odds Ratios and Relative Risk; ROC Analysis	Mackenzie
Fri 14 Jul	Workshop 6	Between-Group Inferences 4: Analysis of Variance and Multiple Comparisons	Azucenas
Learning Module 4	**Experimental Design; Survival Analysis; Power Analysis and Sample-Size Estimation; Rigor and Reproducibility**		
Asynchronous	Lecture 7	Experimental Design; Multifactorial Analysis	Lorenz
Asynchronous	Mini-Lecture 8	Survival Analysis	Mackenzie
Asynchronous	Lecture 9	Power Analysis and Sample-Size Estimation; Rigor and Reproducibility	Mackenzie
Tue 18 Jul	**Mid-Term Exam:** Multiple-Choice and Short Answer Format, 2:00 pm **Administered in Canvas with Honorlock Proctoring** (Mid-Term Exam covers material from Modules 1–3. Time limit: 1 h.)		

Wed 19 Jul	Recitation for Lectures 7–9	Experimental Design; Survival Analysis; Power Analysis and Sample-Size Estimation; Rigor and Reproducibility	Mackenzie
Fri 21 Jul	Workshop 9	Survival Analysis; Power Analysis and Sample-Size Estimation; Rigor and Reproducibility	Azucenas
Mon 24 Jul	**Assignment 2** | Decision tree for between-group inferences | Due 5:00 pm		
Learning Module 5	**Correlation and Regression; Multiple Linear Regression; Logistic Regression; Model Improvements**		
Asynchronous	Lecture 10	Correlation and Regression	Azucenas
Asynchronous	Lecture 11	Multiple Linear Regression; Logistic Regression; Model Improvements	Mackenzie
Tue 25 Jul	Recitation for Lectures 10–11	Correlation and Regression; Multiple Linear Regression; Logistic Regression; Model Improvements	Azucenas
Wed 26 Jul	Workshop 10	Correlation and Regression	Azucenas
Fri 28 Jul	Workshop 11	Multiple Linear Regression; Logistic Regression; Model Improvements	Mackenzie
Learning Module 6	**Statistical Reporting, Transparency, Data Presentation, and Graphic Integrity**		
Asynchronous	Lecture 12	Statistical Reporting, Transparency, Data Presentation, and Graphic Integrity	Mackenzie
Tue 1 Aug	Recitation for Lecture 12	Statistical Reporting, Transparency, Data Presentation, and Graphic Integrity	Mackenzie
Wed 2 Aug	Workshop 12 and Review	Statistical Reporting, Data Presentation, Reporting Results | Review Workshop	Mackenzie
Fri 4 Aug	**Final Exam:** Multiple-Choice Test, 4:00 pm **Administered in Canvas with Honorlock Proctoring** (Final Exam covers material from the entire course with an emphasis on Modules 7–12. Time limit: 1 h.)		
Learning Module 7	**Critiquing Experimental Design and Statistical Analyses of Published Articles**		
Sat 5 Aug	**Assignment 3** | Critique | Due 5:00 pm		
Sat 5 Aug	**Assignment 4** | Have you achieved your goals? | Due 5:00 pm		