DEPARTMENT: BIOS

COURSE NUMBER: 560R **SECTION NUMBER:** 1

CREDIT HOURS: 2 **SEMESTER:** Spring 2021

COURSE TITLE: Applied Bayesian Analysis

CLASS HOURS AND LOCATION: TBD

INSTRUCTOR NAME: Howard Chang

INSTRUCTOR CONTACT INFORMATION

EMAIL: howard.chang@emory.edu

SCHOOL ADDRESS OR MAILBOX LOCATION: GCR 358

OFFICE HOURS: Fridays 9-11am via Zoom (https://zoom.us/j/6774707134).

Teaching Assistant(s): NA

COURSE DESCRIPTION

This course will provide a practical introduction to Bayesian analysis with an emphasis on working with complex hierarchical models and interpreting results from a Bayesian perspective. When appropriate, technical justifications are provided to illustrate model assumptions. Students will gain sufficient knowledge in Bayesian inference and modeling techniques to facilitate future independent research on specific analytical or methodological problems. R and JAGS will be used for computing.

Prerequisites: BIOS 507 or permission from the instructor. Students should be familiar with matrix-based multiple regression, probability theory, and programming with R.

COURSE LEARNING OBJECTIVES:

- Analyze continuous data using linear regression models and discrete data using generalized linear models.
- Analyze right-censored data with time-to-event regression models.
- Analyze correlated data (longitudinal and multi-level) using mixed effect models.
- Assess the impacts of assumptions in advanced statistical analysis using probability and statistical theory.

- Apply concepts in probability and statistical theory to define performance or extend basic statistical analysis techniques.

EVALUATION

Four take-home projects will be assigned. Each project will consist of 2 to 4 stand-alone data analysis problems. Response to each question will be presented in a report form with structured paragraphs. The report will be graded for clarity, succinctness, and presentation. All work must be independent.

Assignment 1 (15%)
Assignment 2 (20%)
Assignment 3 (30%)
Assignment 4 (35%)

COURSE STRUCTURE

There is no assigned textbook. Lecture notes, supplementary journal articles and book chapters will be provided on CANVAS.

Additional References:

- For a more in-depth discussion of Bayesian analysis: *Bayesian Data Analysis*. Gelman, Carlin, Stern, and Rubin (2013).
- The BUGS Book: a Practical Introduction to Bayesian Analysis. Lunn, Jackson, Best, Thomas, Spiegelhalter (2013).
- For a more mathematical introduction to Bayesian analysis: *A First Course in Bayesian Statistical Methods*, Hoff (2010).
- For an introduction to the computational aspect of Bayesian analysis: *Bayesian Core*, Marin and Robert (2007).

All course materials will be posted via Canvas. These include:

- Topic modules and learning objectives
- Lecture slides
- Lecture recording and any written notes during the session
- Programming tutorial with R code or RMarkdown file
- Datasets used for example analysis and homework
- Assignments and solution keys

Attendance Policies Due to the unusual nature of the semester, communication is important. The different course delivery modes are designed to provide some flexibly in attendance. If your situation changes regarding health, housing, or in any other regard with respect to your ability to participate in the class, please contact the appropriate Emory support units first, and then the instructor as soon as feasible.

CLASS SESSION RECORDING

Recordings for all lectures will only be posted on course Canvas. Lectures and other classroom presentations presented through video conferencing and other materials posted on Canvas are for the sole purpose of educating the students enrolled in the course. The release of such information (including but not limited to directly sharing, screen capturing, or recording content) is strictly prohibited, unless the instructor states otherwise. Doing so without the permission of the instructor will be considered an Honor Code violation and may also be a violation of other state and federal laws, such as the Copyright Act. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live.

COMPETENCIES

Foundational Competencies:

- Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate
- Interpret results of data analysis for public health research, policy and practice

Concentration Competencies:

- Design clinical and observational studies, including sample size estimation, in collaborative research teams.
- Use statistical software for data management and exploratory data analysis.
- Apply regression modeling techniques for continuous, categorical, time-to-event, longitudinal and multilevel data.

COURSE POLICIES

As the instructor of this course, I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and the Office for Equity and Inclusion, 404-727-9877.

Without prior approval, no late assignments will be accepted after the solutions have been posted (usually within 2 days). 20% in grade will be deducted for late homework. Questions about graded homework should be addressed within 2 weeks of receiving the graded assignment. Weights for missed midterm exam for approved emergencies/events will be assigned to the final exam.

RSPH POLICIES

Accessibility and Accommodations

Accessibility Services works with students who have disabilities to provide reasonable accommodations. In order to receive consideration for reasonable accommodations, you must contact the Office of Accessibility Services (OAS). It is the responsibility of the student to register with OAS. Please note that accommodations are not retroactive and that disability accommodations are not provided until an accommodation letter has been processed.

Students who registered with OAS and have a letter outlining their academic accommodations are strongly encouraged to coordinate a meeting time with me to discuss a protocol to implement the accommodations as needed throughout the semester. This meeting should occur as early in the semester as possible.

Contact Accessibility Services for more information at (404) 727-9877 or accessibility@emory.edu. Additional information is available at the OAS website at http://equityandinclusion.emory.edu/access/students/index.html

Honor Code

You are bound by Emory University's Student Honor and Conduct Code. RSPH requires that all material submitted by a student fulfilling his or her academic course of study must be the original work of the student. Violations of academic honor include any action by a student indicating dishonesty or a lack of integrity in academic ethics. *Academic dishonesty refers to cheating, plagiarizing, assisting other students without authorization, lying, tampering, or stealing in performing any academic work, and will not be tolerated under any circumstances.*

The RSPH Honor Code states: "Plagiarism is the act of presenting as one's own work the expression, words, or ideas of another person whether published or unpublished (including the work of another student). A writer's work should be regarded as his/her own property."
(http://www.sph.emory.edu/cms/current_students/enrollment_services/honor_code.html)

COURSE OUTLINE

Tentative Topics and Schedule

Week	Lecture Topics	Computation/Modeling Topics
Jan 25	Probability concepts and statistical inference, Bayes Theorem, motivations for Bayesian analysis	Introduction to R programming
Feb 1	Bayesian inference for univariate parameter: binomial proportion, Poisson mean, Gaussian mean and variance	Random variable simulation, Monte Carlo-based inference
Feb 8	Multivariate inference, Bayesian computation (Gibbs sampler, random-walk Metropolis-Hastings)	Markov chain Monte Carlo (MCMC) in R and JAGS
Feb 15	Prior distributions (Jeffrey's, informative, improper)	Bayesian clinical trial and sample size estimation
	Project #1	
Feb 22	Bayesian linear regression, g-prior, posterior prediction	Bayesian model checking
Mar 1	Bayesian hierarchical model, random effects, exchangeability	Bayesian inference for random effects
Mar 8	Bayesian generalized linear model (logistic, Poisson)	MCMC diagnostics and MCMC convergence issues
	Project #2	
Mar 15	Reading Day – No Class	
Mar 22	Bayesian model comparison: information criteria, Bayes factor, posterior predictive loss	Finite mixture model
Mar 29	Penalized regression and Bayesian variable selection	LASSO, ridge-regression, spike-and-slab, horseshoe
Apr 5	Bayesian latent variable modeling	Probit regression, factor analysis
	Project #3	
Apr 12	Bayesian Gaussian process modeling	Time-series and spatial models
Apr 19	Bayesian Dirichlet processes	Bayesian non-parametric models
Apr 26	Advanced Bayesian computation: posterior approximation, Hamiltonian MCMC	Introduction to INLA and STAN
May 5	Catch-up	
Exam Period	*Project #4*	