Fall 2017

BIOS 9231 - Bayesian Statistics I

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Georgia Southern University
Jiann-Ping Hsu College of Public Health

BIOS 9231: Bayesian Statistics I

Fall 2016

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Class Time: Monday, 2:30-5:15 PM
Location: 1008 Hendricks Hall
Office Hours: Tuesdays and Wednesdays: 1:00 - 4:00 PM; and by appointment

Course Catalog available at:
http://em.georgiasouthern.edu/registrar/resources/catalogs/
under Jiann-Ping Hsu College of Public Health Programs

Prerequisites: BIOS 9131 and BIOS 9133

Course Credit: This is a three-credit hour course designed for the DrPH core curriculum.

Course Structure: This course is an in-person meeting class.

Course Description: This course provides the student with an introduction Bayesian analysis and compares Bayesian methods to that of frequentists. The course includes selection of prior distributions, computing posterior distributions, and conjugate models such as the Beta-Binomial, Normal-Normal, and Gamma-Poisson models. Bayesian inference using point and interval estimation, Bayesian hierarchical models, and exchangeability will be explored. Topics including Empirical Bayes versus a fully Bayes approach, Markov Chain Monte Carlo methods and model checking using Bayes factors and sensitivity analyses will be included. Prerequisite: A minimum grade of "B" in BIOS 9131, or permission from instructor.

Text: Gelman, A., Carlin, J.B., Stern, H.S., and Rubin, D.B. (2014) *Bayesian Data Analysis, Third Edition.* Boca Raton, FL: Chapman & Hall/CRC Press.

References:

Ronald Christensen, Wesley Johnson, Adam Branscum and Timothy Hanson. (2011). Bayesian Ideas and Data Analysis: Introduction For Scientists and Statisticians. : Chapman & Hall/CRC Press.

Berry, D.A. and Stangl, D.K. (1996) *Bayesian Biostatistics.* New York, NY: Marcel Dekker.
Moye, L.A. (2008) *Elementary Bayesian Biostatistics.* Boca Raton, FL: Chapman & Hall/CRC Press.

Albert, J. (2007) *Bayesian Computation with R.* New York, NY: Springer.

Gilks, W.R., Richardson, S., and Spiegelhalter, D.J. (1996) Markov *Chain Monte Carlo in Practice.* Boca Raton, FL: Chapman & Hall/CRC Press.

Bolstad, W.M. (2004) *Introduction to Bayesian Statistics*. Hoboken, NJ: John Wiley & Sons, Inc.

Dr.PH Core Student Learning Outcomes (CORE)

1. Demonstrate their readiness to work with communities to address public health problems.
2. Select and apply theoretically based interventions to address public health problems.
3. Apply appropriate research methods to address community health problems, particularly among rural and underserved populations.

Dr.PH Biostatistics Concentration Student Learning Outcomes

1. Construct a public health and biomedical research questions from ideas, conditions, and events that exist in a rural and urban community, region, state, and nation using critical thinking skills.
2. Demonstrate required skills for translating public health practice objectives to appropriate biostatistical framework for analysis and interpretation of results.
3. Illustrate sufficient substantive knowledge of advanced biostatistical methods such as multiple regression, logistic regression, survival analysis, longitudinal data analysis, and Bayesian and adaptive methods to interact with biostatisticians and realted public health researches in a meaningful and productive fashion.
4. Communicate biostatistical principles and concepts to lay and professional audiences through both oral and written communication.

Dr.P.H Biostatistics Concentration Competencies*:*

1. Design a public health and biomedical investigation in terms of the experimental design, data to be collected that reflect research objectives, number of subjects needed, and specification of appropriate methods for analysis.
2. Analyze public health and biomedical data using appropriate statistical software such as SAS, R and S-plus.
3. Interpret analytic methods used in the public health and biomedical journals, as well as critique published reports of public health and biomedical experiments as to the validity of the inferential conclusions.

4. Develop new biostatistical methods and new ideas for applying existing biostatistical methods to applications in public health and the biomedical sciences.
5. Develop written and oral reports to communicate effectively with research investigators the pivotal aspects of a study, including: design, study objectives, data analysis methodology, results and conclusions.
6. Create a collaborative environment for working on written and oral reports.

Performance Based Objectives:

1. Understand how to compare Bayesian to Classical approaches of biostatistical analyses and distinguish conditions for when a Bayesian approach is similar, or equivalent, to a frequentist approach of analysis. (Activates 1, 2 and 3)
2. Understand and use the commonly used Bayesian methodological concepts and apply conjugate models, such as the Beta-Binomial, Normal-Normal, or Gamma-Exponential models, to public health and biomedical data in order to obtain closed-form conditional distributions. (Activates 1, 2 and 3)
3. Understand how to solve single-parameter and multi-parameter Bayesian biostatistical problems for calculating posterior distributions and how to choose the prior distribution in Bayesian analyses in public health and biomedical literature. (Activates 1, 2 and 3)
4. Demonstrate use of the Bayesian statistical software package R and WinBUGS or Stan to compute posterior distributions and their characteristics such as posterior means and credible intervals and understand how interpret credible intervals and other Bayesian results in the context of a public health and biomedical data analysis. (Activates 1, 2 and 3)
5. Understand how to use Markov Chain Monte Carlo (MCMC) methods for public health and biomedical applications and demonstrate the use of MCMC methods using a statistical software package, such as R and WinBUGS/Stan, for public health and biomedical applications. (Activates 1, 2 and 3)

Assessment of students Learning

Activity 1: Use course lectures and class discussions to explain the basic terminology and definitions of Bayesian and compare it to classical approaches of biostatistical analyses and distinguish conditions for when a Bayesian approach is similar, or equivalent, to a frequentist approach of analysis. Also, understand and use the commonly used Bayesian methodological concepts and apply conjugate models, such as the Beta-Binomial, Normal-Normal, or Gamma-Exponential models, to public health and biomedical data in order to obtain closed-form conditional distributions; understand how to solve single-parameter and multi-parameter Bayesian biostatistical problems for calculating posterior distributions and how to choose the prior distribution in Bayesian analyses in public health and biomedical literature. Competence in basic terminology will be evaluated using two activities: (1) weekly homework (2) two in class exams.

Activity 2: Use course lectures, class discussions and class exercises to illustrate the use of the Bayesian statistical software package R and WinBUGS to compute posterior

distributions and their characteristics such as posterior means and credible intervals and understand how interpret credible intervals and other Bayesian results in the context of a public health and biomedical data analysis and understand how to use Markov Chain Monte Carlo (MCMC) methods for public health and biomedical applications and demonstrate the use of MCMC methods using a statistical software package, such as R and WinBUGS, for public health and biomedical applications. Competence in will be evaluated using two activities: (1) weekly homework (2) two take home exams.

Activity 3: Use course lectures, class discussions and real theoretical illustration to explain the basic applications of the Bayesian approach as well as the integration of the Bayesian theories and applications across the biostatistics and public health spectrum. Competence in ability to integrate theories will be evaluated using challenging theoretical published papers for the students to write a report and present the theoretical concept of these papers in the class.

Computing: In a world where technology is increasingly pertinent to everyday tasks, we will learn how the statistical software packages R and WinBUGS/Stan are used in simplifying Bayesian computation and analyses. Both of these software are free downloads from the internet, so you will need to download both programs to your personal computer if you choose to use these software away from the university. Otherwise, the Public Health Computer Lab (1002 Hendricks Hall) will have R and WinBUGS loaded on the computers.

Course Outline:

Tentative Schedule	*Topic*	*Chapters*	*Homework*
Week 1	Probability and inference	Notes & Chapter 1	TBA
Week 2	Single-parameter model	Notes & Chapter 2	TBA
Week 3, 5	Introduction to multi-parameter Models	Notes & Chapter 3	TBA
Week 6	Asymptotic and connections to non-Bayesian	Notes & Chapter 4	TBA
Week 6, 7	Hierarchical Models	Notes & Chapter 5	TBA
Week 8	Model Checking	Notes & Chapter 6	TBA
Week 9	Evaluating comparing and expanding models	Notes & Chapter 7	TBA
Week 11	Decision analysis	Notes & Chapter 9	TBA
Week 11, 12	Introduction to Bayesian computations	Notes & Chapter 10	TBA
Week 12	Basics of Markov chain simulation	Notes & Chapter 11	TBA
Week 13, 14, 16	Regression models and Hierarchical linear models	Notes & Chapter 14, 15	TBA

Samples of your work may be reproduced for search purposes and/or inclusion in the professor's teaching portfolio. You have the right to review anything selected for use, and subsequently ask for its removal.

Instructional Methods: Class meetings will be a combination of lecture, class discussion, and computer software demonstration. Written homework assignments and examinations constitute the basis of student evaluation.

Exam Schedule and Final Examination: Midterm Examination: October 16, 2016
Final Examination: December 4, 2016; 10:00 am -12:00 pm

Grading: Weighting of assignments for purposes of grading will be as follows:

Midterm Exam (25%)	(Learning Objectives: 1, 2, 3)	25 points
Final Exam (25%)	(Learning Objectives: 4, 5)	25 points
Assignments (50%)	(Learning Objectives: 1-5)	50 points
Total Possible Points (100%)		100 points

Academic Misconduct: **"According to the Academic Dishonesty Policy of GSU, Plagiarism includes (but is not limited to):**
A. Directly quoting the words of others without using quotation marks or indented format to identify them.
B. Using published or unpublished sources of information without identifying them.
C. Paraphrasing material or ideas without identifying the source.
D. Unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic material.

If you are accused of plagarism by a JPHCOPH, the following policy, as per the Judicial Affairs website (http://students.georgiasouthern.edu/judicial/faculty.htm) will be enforced:

PROCEDURES FOR ADJUDICATING ACADEMIC DISHONESTY CASES

First Offense - In Violation Plea

1. If the professor and the Dean of Students agree that the evidence is sufficient to warrant a charge of academic dishonesty, the professor should contact the Office of Judicial Affairs to determine if this is a first violation of academic dishonesty. The incident will be reported via the following website:

http://students.georgiasouthern.edu/judicial/faculty.htm

2. If it is a first violation, the professor should talk with the student about the violation. If the student accepts responsibility in writing and the professor decides to adjudicate the case, the following procedures will be followed:

a. The student will be placed on disciplinary probation for a minimum of one semester by the Office of Judicial Affairs.

b. The student will be subject to any academic sanctions imposed by the professor (from receiving a 0 on the assignment to receiving a failing grade in the class).

c. A copy of all the material involved in the case (Academic Dishonesty Report Form and the Request For Instructor to Adjudicate Form) and a brief statement from the professor concerning the facts of the case and the course syllabus should be mailed to the Office of Judicial Affairs for inclusion in the students discipline record.

First Offense - Not In Violation Plea (student does not admit the violation)

If the professor and the Dean of Students agree that the evidence is sufficient to warrant a charge of academic dishonesty, the professor should contact the Office of Judicial Affairs to determine if this is the first or second violation of academic dishonesty. The student will be charged with academic dishonesty and the University Judicial Board or a University Hearing Officer would hear the case. If the student is found responsible, the following penalty will normally be imposed:

a. The student will be placed on Disciplinary Probation for a minimum of one semester by the Office of Judicial Affairs.

b. The student will be subject to any academic sanctions imposed by the professor.

Second Violation of Academic Dishonesty

If the professor and the Dean of Students agree that the evidence is sufficient to warrant a charge of academic dishonesty, and if it is determined this is the second violation, the student will be charged with academic dishonesty and the University Judicial Board or a University Hearing Officer

would hear the case.If the student is found responsible, the following penalty will normally be imposed:
a. Suspension for a minimum of one semester or expulsion.
b. The student will be subject to any academic sanctions imposed by the professor.

NOT RESPONSIBLE FINDING

When a student is found not responsible of academic dishonesty, the work in question (assignment, paper, test, etc.) would be forwarded to the Department Chair. It is the responsibility of the Department Chair to ensure that the work is evaluated by a faculty member other than the individual who brought the charge and, if necessary, submit a final grade to the Registrar. For the protection of the faculty member and the student, the work in question should not be referred back to the faculty member who charged the student with academic dishonesty.

In the case of a Department Chair bringing charges against a student, an administrator at the Deans level will ensure that the students work is evaluated in an appropriate manner.

Academic Handbook: Students are expected to abide by the Academic Handbook, located at http://students.georgiasouthern.edu/sta/guide/. Your failure to comply with any part of this Handbook may be a violation and thus, you may receive an F in the course and/or be referred for disciplinary action.

University Calendar for the Semester: The University Calendar is located with the semester schedule, and can be found at: http://www.collegesource.org/displayinfo/catalink.asp.

Attendance Policy: Federal regulations require attendance be verified prior to distribution of financial aid allotments. Attendance will not be recorded after this initial period.

One Final Note: The contents of this syllabus are as complete and accurate as possible. The instructor reserves the right to make any changes necessary to the syllabus and course material. The instructor will make every effort to inform students of changes as they occur. It is the responsibility of the student to know what changes have been made in order to successfully complete the requirements of the course.