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# 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 2019

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**Class Time**: Monday, 2:30-5:15 PM
**Location**: 1008 Hendricks Hall
**Office Hours**:  Wednesday 9:30 - 12:00 PM and Thursdays 9:30 - 12:00 AM; 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

**FOLIO Access**:  https://my.georgiasouthern.edu/portal/portal.php

*Access to course materials are available for up to one year after graduation.*

**Catalog 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.

**Recommended Textbook:**

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 Texts**:

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.

## CEPH Concentration Competencies

1. 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.
2. Analyze public health and biomedical data using appropriate statistical methods and demonstrate the proficiency in statistical software such as SAS and R.
3. Develop new biostatistical methods and new ideas for applying existing biostatistical methods to applications in public health and the biomedical sciences.
4. Demonstrate the ability to incorporate prior knowledge to solve biomedical problems via Bayesian analysis.
5. Demonstrate the cognition of the underlying statistical theory that supports the biostatistical methodology.

## CEPH DrPH Competencies

**Data & Analysis**
1.  Explain qualitative, quantitative, mixed methods and policy analysis research and evaluation methods to address health issues at multiple (individual, group, organization, community and population) levels
2.  Design a qualitative, quantitative, mixed methods, policy analysis or evaluation project to address a public health issue
3. Explain the use and limitations of surveillance systems and national surveys in assessing, monitoring and evaluating policies and programs and to address a population's health

**Leadership, Management & Governance**
4. Propose strategies for health improvement and elimination of health inequities by organizing stakeholders, including researchers, practitioners, community leaders and other partners
5. Communicate public health science to diverse stakeholders, including individuals at all levels of health literacy, for purposes of influencing behavior and policies

6. Integrate knowledge, approaches, methods, values and potential contributions from multiple professions and systems in addressing public health problems
7. Create a strategic plan
8. Facilitate shared decision making through negotiation and consensus-building methods
9. Create organizational change strategies
10. Propose strategies to promote inclusion and equity within public health programs, policies and systems
11. Assess one's own strengths and weaknesses in leadership capacities including cultural proficiency
12. Propose human, fiscal and other resources to achieve a strategic goal
13. Cultivate new resources and revenue streams to achieve a strategic goal

**Policy & Programs**
14. Design a system-level intervention to address a public health issue
15. Integrate knowledge of cultural values and practices in the design of public health policies and programs
16. Integrate scientific information, legal and regulatory approaches, ethical frameworks and varied stakeholder interests in policy development and analysis
17. Propose interprofessional team approaches to improving public health

**Education & Workforce Development**
18. Assess an audience's knowledge and learning needs
19. Deliver training or educational experiences that promote learning in academic, organizational or community settings
20. Use best practice modalities in pedagogical practices

**<u>Performance Based Objectives</u>**:

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. (Activities 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. (Activities 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. (Activities 1, 2 and 3)
4. Demonstrate use of the Bayesian statistical software package R and JAGS 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. (Activities 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 JAGS/Stan, for public health and biomedical applications. (Activities 1, 2 and 3)

<u>**Assessment of students Learning**</u>
**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 JAGS 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 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 JAGS or STAN, 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.

<u>**Computing**</u>: In a world where technology is increasingly pertinent to everyday tasks, we will learn how the statistical software packages R and JAGS/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 JAGs loaded on the computers.

<u>**Course Outline:**</u>

**Overview of the content to be covered the semester:**

| *Tentative Schedule* | *Topic* | *Chapters* | *Homework* |
|---|---|---|---|
| Week 1 | Probability and inference | Notes & Chapter 1 | Homework 1 |
| Week 2 | Single-parameter model | Notes & Chapter 2 | Homework 2 |
| Week 3, 5 | Introduction to multi-parameter Models | Notes & Chapter 3 | Homework 3 |
| Week 6 | Introduction to Bayesian computations | Notes & Chapter 10 | |
| Week 7, 8 | Hierarchical Models | Notes & Chapter 5 | Homework 4 |
| Midterm | | | |
| Week 9 | Model Checking | Notes & Chapter 6 | |
| Week 10, 11 | Regression models | Notes & Chapter 14 | Homework 5 |
| Week 13, 14, 16 | Hierarchical linear models | Notes & Chapter 15 | Homework 6 |

**Grading Scheme**:
Assignments (assesses competencies 1-17): 30%
Midterm Exam (assesses competencies 1-11): 30%
Final Exam (assesses competencies 1-17): 40%

Note: All exams and assignments will be graded and returned promptly so that students may accurately calculate their grades at any point in time during the semester.

**Grading Scale**:
A        90 - 100%
B        80 - 89%
C        70 - 79%
D        60 - 69%
F        0 - 59%

**Exams**: There will be 2 exams, the midterm exam and the final exam.

**Assignments**: Assignments account for 30% of your course grade. You may work together or individually on these assignments, however each student must submit his/her own assignment and state with whom he/she worked, if applicable.

What does 'working together' mean? You are welcome to solve problems and discuss explanations in groups, however **it is not acceptable to submit assignments with identical wordings and explanations**.

**Schedule of Exams**:

**MIDTERM EXAM:**
**FINAL EXAM:**

## Portfolio Inclusion

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 active participation. Computer-generated presentations will be used in the lecture portion of this course. Prior to each lecture, the student is encouraged to complete the recommended readings and actively participate in class discussions. In this way, it is hoped that the learner will be better prepared to successfully accomplish the learning objective of each lecture experience.*

## General Expectations

1.      For every one-credit hour, you should expect to work roughly two hours outside the classroom each week. For example, for a three credit hour course, during a regular fifteen week semester, you should expect approximately ninety hours of work outside of class.

2.      Students are expected to keep up with the class, to read the required material, and to submit assignments and activities by due dates and times.

3.      Students are expected to independently complete all activities, exercises, assignments, and assessments including exams.

4.      Students are expected to produce quality work. Typos and grammar errors should be kept to a minimum. The format and readability of submissions will be taken into consideration when assigning a grade.

**5.**      Remember to check when assignments are due. It is recommended that you stay ahead of schedule on the assignments, so if an emergency happens, your assignment will be completed and ready to submit within the designated time frame. It is your responsibility to keep track of the due dates for each assignment.

## Response Times

During a normal work week (i.e., Monday 9:00 AM through Friday 5:00 PM) students can expect responses as follows:

•      Email: within 48 hours

- Discussion posts: within 72 hours
- Assignment grades: within 72 hours of submission date.

Exceptions:  I may not check FOLIO or GSU email over the weekends.  If you send me an email after 5:00 PM on Friday, please do not expect a response until the following Monday.

All assignments will be graded promptly so that students may accurately calculate their grades at any point in time during the semester. There are times when extraordinary circumstances occur (e.g., serious illness, death in the family, etc.).  In such circumstances, and/or if you need additional time to satisfactorily complete any course requirement, please consult with the instructor within a reasonable amount of time. Extensions are not guaranteed and will be granted solely at the discretion of the instructor.

## Course Expectations

## Texting and Use of Cell Phones (and Other Technologies)

Please do not text in class or use your cell phone during class!  Texting during class (or in a meeting) is disruptive and rude…at least to me.  My preference is that you put cell phones away during class meetings so they are not a source of temptation.  Offenders will be asked to leave.

## Class Attendance and Participation Policy

Federal regulations require attendance be verified prior to distribution of financial aid allotments.  Regular attendance is expected.  Your attendance will be verified at the first regular class session.

It is the policy of the University to permit students, faculty, and staff to observe those holidays set aside by their chosen religious faith. The faculty should be sensitive to the observance of these holidays so that students who choose to observe these holidays are not seriously disadvantaged. It is the responsibility of those who wish to be absent to make arrangements in advance with their instructors.

Students participating in authorized activities as an official representative of the University (i.e., athletic events, delegate to regional or national meetings or conferences, participation in university-sponsored performances, and **JPHCOPH funded**) will not receive academic penalties and, in consultation with the instructor of record, will be given reasonable opportunities to complete assignments and exams or given compensatory assignment(s) if needed. The student must provide written confirmation from a faculty or staff advisor to the course instructor(s) at least 10 days prior to the date for which the student will be absent from the class. The student is responsible for all material presented in class and for all announcements and assignments. When possible, students are expected to complete these assignments before their absences. In the event

of a disagreement regarding this policy, an appeal may be made by either the student or the instructor of record to the corresponding college dean. (*University Graduate Catalog*)

## **Academic Misconduct**

As a student registered at this University, it is expected that you will adhere to only the strictest standards of conduct.  It is recommended that you review the latest edition of the *Student Conduct Code* book, as well as the latest *Undergraduate & Graduate Catalog* to familiarize yourself with the University's policies in this regard.  Your continued enrollment in this course is an implied contract between you and the instructor on this issue; from this point forward, it is assumed that you will conduct yourself appropriately.

## **Plagiarism:**

According to the Academic Dishonesty Policy of Georgia Southern University, 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 plagiarism 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 student's 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 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 Dean's level will ensure that the student's work is evaluated in an appropriate manner.

CONFIDENTIALITY
In accordance with provisions of the Family Educational Rights and Privacy Act of 1974 and the Georgia Open Records Act, any information related to a violation of academic dishonesty or the outcome of a judicial hearing regarding academic dishonesty, is prohibited and must be treated as confidential by members of the faculty."

**Accommodations for Individuals with Disabilities**
In compliance with the Americans with Disabilities Act (ADA), Georgia Southern University will honor requests for reasonable accommodations made by individuals with

disabilities. Students must self disclose any disability for which an accommodation is being sought to the
Student Disability Resource Center (SDRC) before academic or other accommodations can be implemented. For additional information, please call the Director of EEO and Title IX at (912) 478-5136 / TDD (912) 478-0273 or the SDRC Director at (912) 478-1566 / TDD (912) 478-0666. The TDD phone numbers are intended for individuals with hearing impairments.

## University Calendar for the Semester
The University Calendar is located with the semester schedule, and can be found at:
http://em.georgiasouthern.edu/registrar/resources/calendars/


## 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 to ensure better student learning.  The instructor will announce any such changes in class. It is the responsibility of the student to know what changes have been made in order to successfully complete the requirements of the course.

This syllabus, my lecture notes, and all materials distributed and presented during this course are protected by copyright law.  You are authorized to take notes in this class but that authorization extends to only making one set of notes for your personal use and no other use.  You are not authorized to sell, license, commercially publish, distribute, transmit, display, or record notes from this class unless you have my written consent to do so.

## STUDENT CONDUCT CODE
The Student Conduct Code is the official University publication governing student conduct and behavior. It is the responsibility of each student to become familiar with the rules and regulations governing student life. Student conduct procedures, appeal procedures, and disciplinary sanctions are found in the Student Conduct Code at http://students.georgiasouthern.edu/conduct. I acknowledge that I have read and understand this statement referencing the Student Conduct Code.

## ACADEMIC DISHONESTY
The University goal is to foster an intellectual atmosphere that produces educated, literate people. Because cheating and plagiarism are at odds with that goal, they shall not be tolerated in any form. Students are expected to adhere to the rules and regulations as set forth in the Student Conduct Code. Therefore, all work submitted by a student must represent that student's own ideas and effort; when the work does not, the student has engaged in academic dishonesty. Plagiarism occurs when a person passes in another person's work as his or her own, borrows directly from another person's work without proper documentation, and resubmits his or her own work that has been previously submitted without explicit approval from the instructor. For example, academic dishonesty occurs whenever a student participates in any of the following: Cheating submitting material that is not yours as part of your course performance; using

information or devices that are not allowed by the faculty; obtaining and/or using unauthorized materials; fabricating information, research, and/or results; violating procedures prescribed to protect the integrity of an assignment, test, or other evaluation; collaborating with others on assignments without the faculty's consent; cooperating with and/or helping another student to cheat; demonstrating any other forms of dishonest behavior. Plagiarism directly quoting the words of others without using quotation marks or indented format to identify them; using sources of information (published or unpublished) without identifying them; paraphrasing materials or ideas without identifying the source; self-plagiarism - resubmitting work previously submitted without explicit approval from the instructor; unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic material. NOTICE: The list above is intended only to provide general guidelines for recognizing and avoiding common types of academic dishonesty. It is in no way an exhaustive or comprehensive list of all the types of academic dishonesty. For more information about academic honesty, see the Student Conduct Code at http://students.georgiasouthern.edu/conduct. I acknowledge that I have read and understand the Academic Dishonesty Policy.


I have read the syllabus and understand the contents and course requirements.


_____    _____    _____

Student Name (print)        Student Signature          Date